Improved Performance Research Integration Tool (IMPRINT)

Analysis Guide

Version 5.0

September 1999

US Army Research Laboratory
Human Research and Engineering Directorate

DRAFT

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IMPROVED PERFORMANCE RESEARCH INTEGRATION TOOL (IMPRINT) ANALYSIS GUIDE

The purpose of the Improved Performance Research Integration Tool (IMPRINT) Analysis Guide is to provide a description of the major types of analyses that can be performed in IMPRINT. The format for describing each type of analysis is:

- The goals and expected results of the analysis
- The mental model you should have when performing this type of analysis
- Special Guidance on the limitations or policies that might impact the analysis
- Data requirements for the analysis
- Major steps in performing the analysis

Each chapter in this document describes a separate analysis process. This document is intended to be used with the IMPRINT User's Guide. For additional documentation regarding the details of how to apply specific IMPRINT capabilities, we recommend that you refer to the appropriate chapter in the IMPRINT User's Guide.

Chapter 1 - Crew Performance

Goals and Results

IMPRINT assists you in estimating the likely performance of a new weapon system by helping you build models of each operational mission the system will be required to accomplish. Since it is typically easier to describe the mission by breaking it into smaller “sub” functions than describing the mission as a whole, you build these models by breaking down the mission into a network of functions. Each of the functions is then further broken down into a network consisting of other functions and tasks. Next, you estimate the time it will take to perform each task, the likelihood that it will be performed accurately, and the workload associated with each task.

Finally, by executing a simulation model of the mission, you can study the range of results that will occur in the mission, functions and tasks. Additionally, at the completion of the simulation, IMPRINT can compare the minimum acceptable mission performance time and accuracy to the predicted performance. This will determine whether the mission met its performance requirements.

Mental Model

In IMPRINT, the operations modeling capability can be used to examine any process that you can describe as a flow of tasks. Even though the examples in IMPRINT are all operational missions, you could use this capability to model a maintenance or logistics process.

You can also think of the process of developing a model, running it, and analyzing results in much the same way you would think of designing, executing, and analyzing an experiment. In this vein, you should first determine what questions you want to answer with this analysis. The operations modeling capability can answer questions such as:

- How many people do I need to perform this process within my time constraints?
- How long will it take to perform this process?
- How “risky” is the process (i.e., what is the probability of success)?

After you have defined the questions you are trying to answer, you should select your dependent and independent variables. Then, you should design your analysis process. After these items have been determined, you will be better equipped to design a model that will be responsive to your analytical needs.

It is also much easier to debug a model if you add parameters to it in an incremental fashion. In other words, you should lay out the network diagram first, then add task times. Next, execute the model to be sure the branching logic is running the way you expect. If everything seems to be working in the way you intended, then you can go back to the tasks and add accuracy information. Run the model again to check that your accuracy data have had an effect that makes sense to you. Then, consider whether you would add taxon and stressor information. By moving through your analysis in an incremental way, you can simplify the process of verifying that IMPRINT is interpreting your model in the way you expected.

It is often difficult to find sources of data for this type of model. While IMPRINT can provide you some help in this area (e.g., libraries of existing models, inclusion of human performance micromodels), you will need to try identifying sources of data. You may be able to get some data from the Operational Requirements Document (ORD) of your system, test and evaluation reports of a predecessor, but similar system, or from subject matter experts on your system. If data elements exist for which you do not have any existing data, we recommend that you identify the most likely and worst case values for these elements. You can then run the IMPRINT model iteratively to determine how sensitive the model results are to the variability of these data items. If the model is not very sensitive to the values in question, then you probably do not need to invest a lot of resources in finding better data. If the model is very sensitive, then you can either work to improve the quality of your data, or you can provide a decision maker with information on the most likely and worst case results.

Special Guidance

If you want to refer to a specific Military Occupational Specialty (MOS) in your analysis, you must first go to the Define Soldiers menu option and add the MOS to your analysis. You can do this by either copying from an existing library system, or by accessing the directory of MOS's provided in the Define Soldiers capability. This process is described in Chapter 6, "Soldier Characteristics," in this Analysis Guide.

Data Requirements

The data in an IMPRINT operational mission analysis are hierarchically organized. Below, we describe the data elements, and indicate which are required, and which are optional. You should be aware that in IMPRINT, we attempt to provide defaults for every data element that is required. For this reason, even though a data element is "required" you may not actually have to enter it yourself. In fact, an IMPRINT operational mission will run as soon as you have drawn a task network. This is because the required data items (e.g., task time, task accuracy estimate) default to values that enable the model to run.

Note that each data element is defined in the glossary provided in the IMPRINT User's Guide.

IMPRINT Level	Data Element	Required?	Default Value
Analysis	Name	Yes	
Analysis	Version	Yes	
Analysis	Description	No	
Mission	Name	Yes	
Mission	Time Standard	No	00:00:00.00
Mission	Time Criterion	No	0.00

Mission	Accuracy Criterion	No	0.00
Mission	Mission Criterion	No	0.00
Mission	Description	No	
Function	Name	Yes	Unnamed #
Function	Time Standard	No	00:00:00.00
Function	Criterion	No	0.00
Function	Branching Logic	Yes	
Task	Name	Yes	Unnamed #
Task	Time Standard	No	00:00:00.00
Task	Accuracy Standard	No	0.00 Percent Steps Correct
Task	Estimated Time	Yes	00:00:00.00
Task	Time Standard Deviation	No	00:00:00.00
Task	Time Distribution	No	Normal
Task	Estimated Accuracy	Yes	0.00
Task	Failure Consequences	Yes	No Effect
Task	Branching Logic	Yes	

Analysis Steps

In this document, we describe the steps required to perform the analysis. You can find a detailed description of how to perform each step in Chapter 3, "Using IMPRINT," of the IMPRINT User's Guide. Additionally, please be aware that the sequence of steps provided in this document is often just one method of performing the analysis. As with most Windows products, the same operations can often be performed just as effectively in a different order.

1. Begin a new analysis - Open IMPRINT. From the **File** menu, choose **New**. You will see a dialog box in which you must enter an Analysis Name and Version. Once entered, choose **OK**.

2. Define Mission - From the **Define** menu, choose **System Mission**. You will see a dialog box that lists the missions that currently exist for your analysis.

3. Add a new mission - Use the **Add** button. Enter a mission name.

4. Enter performance standards - Highlight the mission you just added, and press the **Open** button. You will see the Mission Information dialog. If you want IMPRINT to compare the predicted performance to the required mission performance, then you must enter the mission level performance standards on this dialog. If you do not want this comparison, then you can leave all the text boxes with the default information.

5. Go to the task network diagram - Press the **Functions + Tasks** button to get to the list of functions and tasks at the top level of your mission. You can enter the functions

and tasks using these lists, or you can proceed to the network diagram and use the drawing space to illustrate your network.

6. Draw a network to show task sequence - Press the **Network Diagram** button. The network diagram will be blank except for the start and end functions that are required in each mission. Use the tool bar and select the **Function** or **Task** tool. Click on the network workspace to place the new node. Use the tool bar and select the **Path** tool. Draw paths between your nodes to show the sequence of the tasks and functions. For more detailed information on what each tool on the tool bar is used for, and how to navigate around the network, access IMPRINT on-line help, or see Chapter 3 in the IMPRINT User's Guide.

7. Enter task data - Double click on each task node to view the task information dialog. You will notice that this dialog has tabs along the bottom edge that enable you to view data that are attached to each task in your mission. For this example, we only are interested in information on the **Timing and Accuracy** tab. This is the first tab.

8. Enter time and accuracy predictions - If you want IMPRINT to compare predicted performance to required performance at the task level, you must enter the Time and Accuracy Standards and Criteria. In particular, we recommend that you enter the accuracy standard and measure in order to document what you mean by "accurate performance" on this task. This will be helpful to other people who review your mission and it can also be helpful to you when you attempt to estimate the probability of task success. It is important that you enter the **Estimated Task Time** and **Estimated Task Accuracy** data elements. These data elements are used to drive the mission simulation model. You can use the **Previous** and **Next** buttons to move through the tasks within each function of your mission. Enter these data for every task in your mission. You can exit out of the network diagram by using the **Close** box on the network drawing window. Use the **OK** buttons to return to the top level of the mission. IMPRINT will prompt you to save the network diagram.

9. Save your mission - Use the **Save** command on the **File** menu to save your data. We strongly recommend that you use this command often during your IMPRINT session.

10. Execute the Operations Mission - Access the **Execute** menu, and select the **Operations Model** option. Notice that you can vary the number of times you want to run the mission model and the random number seed. Press the **Run Model** button. When the model is finished (it should run very quickly), you will be reminded that you can access the results using the **Reports** menu.

11. View Mission Performance, Function Performance and Task Performance Reports - Access the **Reports** menu in IMPRINT and select the **Operations Model** menu item. Highlight the **Mission Performance Report**, **Function Performance Report** and the **Task Performance Report**, and press the **Reports** button. The Mission Performance Report will tell you the predicted total mission performance time, and whether the

mission was performed accurately. If you entered mission level standards, the predicted results will be compared to the standards. Similarly, the Function Performance Report will provide an estimate of the total simulated time it took to perform each function. If available, this value will be compared to your function time standard. Finally, the simulated results for every task will be provided in the Task Performance Report. This will include the number of times each task occurred in the model, as well as the predicted time for each task and the percentage of times each task was performed accurately. These values will be compared to the task standards.

Chapter 2 - Crew Workload (VACP)

Goals and Results

IMPRINT assists you in estimating the workload associated with the performance of a new weapon system by helping you build task network workload models of each operational mission the system will be required to accomplish. Since it is typically easier to describe the mission by breaking it into smaller pieces than describing the mission as a whole, you build these models by breaking down the mission into a network of functions. Each of the functions is then further broken down into a network consisting of other functions and tasks. Next, you estimate the time it will take to perform each task, the likelihood that it will be performed accurately, and the workload associated with each task.

You can evaluate the workload using the Visual, Auditory, Cognitive, and Psychomotor (VACP) method or the Advanced Workload method. The VACP method is simpler and is intended to be used early in your design process. The Advanced Workload method provides a much more detailed look at the workload issue and enables you to examine the impact of workload management strategies. We recommend that you begin by using the VACP method, and if necessary, apply the Advanced Workload method as your analysis matures. When you change a mission from one method to the other, using the radio button at the bottom of the Define Mission dialog, all your data will be preserved and the relevant data applied to the other analysis.

In the VACP method of workload computation, workload scores are summed within channels (e.g., Visual, Auditory) across concurrent tasks. For example, if the same operator is performing two tasks at once, and the first task has a Visual workload score of 4.1 and the second task has a Visual workload score of 3.2, then for the amount of time the two tasks overlap that operator's total Visual workload score would be 7.3.

When you execute the simulation model of the mission, you will get results that show the workload values over time for each operator of your system. By examining this workload graph, you can determine where the workload peaks are, and which tasks were operating at that time and contributed to the peaks. These tasks are candidates for redesign, automation, or reallocation to another crewmember. Additionally, all capabilities described in the previous chapter, "Crew Performance," are available when you are developing a workload model. Therefore, in addition to providing output regarding the workload, IMPRINT can compare the minimum acceptable mission performance time and accuracy to the predicted performance. This will determine whether the mission has met its performance requirements.

Mental Model

In IMPRINT, the workload modeling capability can be used to examine any process, that you can describe as a flow of tasks. Even though the examples in IMPRINT are all operational missions, you could actually use this capability to model a maintenance or logistics process.

You can also think of the process of developing a model, running it, and analyzing results in much the same way you would think of designing, executing, and analyzing an experiment. In this vein, you should first determine what questions you want to answer with this analysis. The workload modeling capability can answer questions such as:

- How many people do I need to perform this process within my time constraints?
- How much visual, auditory, cognitive and psychomotor effort is involved in performing this process?
- Is the current task allocation strategy balanced?

After you have defined the questions you are trying to answer, you should select your dependent and independent variables. Then, you should design your analysis process. After these items are determined, you will be better equipped to design a model that will be responsive to your analytical needs.

It is also much easier to debug a model if you add parameters to it in an incremental fashion. In other words, you should lay out the network diagram first, then add task times. Next, execute the model to be sure the branching logic is the way you expect. If everything seems to be working in the way you intended, then you can go back to the tasks and add VACP workload information. Run the model again to check that your workload outputs are explainable. If you have defined a high workload definition, IMPRINT will help you reallocate tasks between your crewmembers by assisting in removing all points of overload.

If your system design is mature (i.e., the tasks and their sequence are well understood) and you are interested in a high fidelity workload analysis, you might change your model to an Advanced Workload model and implement some workload management strategies. These are discussed in Chapter 3, “Crew Workload (Advanced)” in this Analysis Guide.

It is often difficult to find sources of data for this type of model. While IMPRINT can provide you some help in this area (e.g., libraries of existing models, inclusion of human performance micromodels), you will need to try identifying sources of data. You may be able to get some time or accuracy data from the Operational Requirements Document (ORD) of your system, test and evaluation reports of a predecessor, but similar system, or from subject matter experts on your system. Workload data are particularly difficult to get. The benchmarked scales in IMPRINT are quite descriptive and have been proven to be very reliable when used by people who are familiar with the system and the tasks. If data elements exist for which you do not have any existing data, we recommend that you identify the most likely and worst case values for these elements. You can then run the IMPRINT model iteratively to determine how sensitive the model results are to the variability of these data items. If the model is not very sensitive to the values in question, then you probably do not need to invest a lot of resources in finding better data. If the model is very sensitive, then you can either work to improve the quality of your data, or you can provide a decision maker with information on the most likely and worst case results.

Special Guidance

The VACP workload data do not dynamically affect simulated mission performance. In other words, if you have high workload during a portion of your mission, there will not be an associated impact on task time or accuracy. Rather, the VACP workload method is meant to be a very simple and quick analysis that will enable you to identify points of high workload and then manually adjust your mission to reallocate tasks.

IMPRINT does have the capability to perform a much more detailed and dynamic workload analysis, in which the task network is changed to accommodate workload levels as the model runs. While this can be a much more realistic and high fidelity analysis, it does require that your tasks be defined very explicitly, with much more detailed data than is used by the VACP method. This capability is referred to as "Advanced Workload" in IMPRINT. If you are interested in this detailed analysis, please refer to Chapter 3, "Crew Workload (Advanced)" in this Analysis Guide for more information.

If you want to refer to specific MOS's in your analysis, you must first go to the **Define Soldiers** menu option and add MOS's to your analysis. You can do this by either copying from an existing library system, or by accessing the directory of MOS's that is provided in the Define Soldiers capability. This process is described in Chapter 6, "Soldier Characteristics" in this Analysis Guide.

Data Requirements

The data in an IMPRINT VACP workload analysis are hierarchically organized. Below, we describe the data elements, indicating which are required, and which are optional. You should be aware that in IMPRINT, we attempt to provide defaults for every data element that is required. For this reason, even though a data element is "required" you may not actually have to enter it yourself. In fact, an IMPRINT workload analysis will run as soon as you have drawn a task network. This is because the required data items (e.g., task time, task workload ratings) default to values that enable the model to run.

Note that each data element is defined in the glossary provided in the IMPRINT User's Guide.

IMPRINT Level	Data Element	Required?	Default Value
Analysis	Name	Yes	
Analysis	Version	Yes	
Analysis	Description	No	
Mission	Name	Yes	
Mission	Time Standard	No	00:00:00.00
Mission	Time Criterion	No	0.00
Mission	Accuracy Criterion	No	0.00

Mission	Description	No	
Mission	Criterion	No	0.00
Mission	Overall Workload Definition	No	
Mission	High Workload Definition	No	
Function	Name	Yes	Unnamed #
Function	Time Standard	No	00:00:00.00
Function	Criterion	No	0.00
Function	Branching Logic	Yes	
Task	Name	Yes	Unnamed #
Task	Time Standard	No	00:00:00.00
Task	Accuracy Standard	No	0.00 Percent Steps Correct
Task	Estimated Time	Yes	00:00:00.00
Task	Time Standard Deviation	No	00:00:00.00
Task	Time Distribution	No	Normal
Task	Estimated Accuracy	No	0.00
Task	Failure Consequences	Yes	No Effect
Task	Operator Assignments	Yes	CrewMember1
Task	Workload Ratings	Yes	
Task	Branching Logic	Yes	

Analysis Steps

In this document, we describe the steps required to perform the analysis. You can find a detailed description of how to perform each step in Chapter 3, “Using IMPRINT,” of the IMPRINT User’s Guide. Additionally, please be aware that the sequence of steps provided in this document is often just one method of performing the analysis. As with most Windows products, the same operations can often be performed just as effectively in a different order.

1. Begin a new analysis - Open IMPRINT. From the **File** menu, choose **New**. You will see a dialog box in which you must enter an Analysis Name and Version. Once entered, choose **OK**.

2. Define Mission - From the **Define** menu, choose **System Mission**. You will see a dialog box that lists the missions that currently exist for your analysis.

3. Add a new mission - Use the **Add** button. Enter a mission name.

4. Enter performance standards - Highlight the mission you just added, and press the **Open** button. You will see the Mission Information dialog. If you want IMPRINT to compare the predicted performance to the required mission performance, then you must enter the mission level performance standards on this dialog. If you do not want this comparison, then you can leave all the text boxes with the default information.

Also, you should leave the radio button at the bottom of the dialog set to **VACP Workload Analysis**.

5. Enter the list of crewmembers for your system - Click on the **Crew** button on the Mission Information dialog. Enter the names of the crewmembers that will perform the tasks in your mission. Click **OK** to return to the Mission Information dialog.

6. Go to the task network diagram - Press the **Functions + Tasks** button to get to the list of functions and tasks at the top level of your mission. You can enter the functions and tasks using these lists, or you can proceed to the network diagram and use the drawing space to illustrate your network.

7. Draw a network to show task sequence - Press the **Network Diagram** button. The network diagram will be blank except for the start and end functions that are required in each mission. Use the tool bar and select the **Function** or **Task** tool. Click on the network workspace to place the new node. Use the tool bar and select the **Path** tool. Draw paths between your nodes to show the sequence of the tasks and functions. For more detailed information on what each tool on the tool bar is used for, and how to navigate around the network, access IMPRINT on-line help, or see Chapter 3, "Using IMPRINT, in the IMPRINT User's Guide.

8. Enter task data - Double click on each task node to view the task information dialog. You will notice that this dialog has tabs along the bottom edge that enable you to view data that are attached to each task in your mission. For this example, we are interested in information on the **Timing and Accuracy** tab, the **Workload** tab, and the **Crew Assgn** tab.

9. Enter time and accuracy predictions - If you want IMPRINT to compare predicted performance to required performance at the task level, you must enter the Time and Accuracy Standards and Criteria. In particular, we recommend that you enter the accuracy standard and measure in order to document what you mean by "accurate performance" on this task. This will be helpful to other people who review your mission and it can also be helpful to you when you attempt to estimate the probability of task success. It is important that you enter the **Estimated Task Time** and **Estimated Task Accuracy** data elements. These data elements are used to drive the mission simulation model. You can use the **Previous** and **Next** buttons to move through the tasks within each function of your mission. Enter these data for every task in your mission.

10. Enter workload predictions - Click on the **Workload** tab for each task. Using the combo boxes next to each workload channel (i.e., Visual, Auditory, Cognitive and Psychomotor), choose the rating on each scale that best describes the task. You can use the **Previous** and **Next** buttons to move through the tasks within each function of your mission. Enter these data for every task in your mission.

11. Assign operators to your tasks - Click on the **Crew Assgn** tab for each task. Assign primary operators for each of your tasks. For any tasks in which other crew members have access to the controls and displays that are needed to perform the tasks and for which they have the training and decision authority to perform the task, use the **Add** button to identify those crew members as secondary operators. You can use the **Previous** and **Next** buttons to move through the tasks within each function of your mission. Enter these data for every task in your mission. You can exit out of the network diagram by using the **Close** box on the network drawing window. Use the **OK** buttons to return to the top level of the mission. IMPRINT will prompt you to save the network diagram.

12. Save your mission - Use the **Save** command on the **File** menu to save your data. We strongly recommend that you use this command often during your IMPRINT session.

13. Enter an Overall Workload definition - Use the **Overall Workload** command under the **Options** menu to enter an expression that will combine the values of the VACP workload channels into a single workload score. This step is optional, and if completed, will provide an additional workload score. It will not replace the standard VACP scores. Many users enter an overall expression that sums the four channels "V+A+C+P."

14. Enter a High Workload definition - Use the **High Workload Definitions** command under the **Options** menu to enter expressions that will be used to mark any areas in your mission as "high workload." You can enter up to four definitions. Note that these definitions will not affect mission performance. Rather, they will only be used to report specific areas of high workload to you.

15. Execute the Operations Mission - Access the Execute menu, and select the **Operations Model** option. Notice that you can vary the number of times you want to run the mission model and the random number seed. Press the **Run Model** button. When the model is finished (it should run very quickly), you will be reminded that you can access the results using the **Reports** menu.

16. View Operator Workload, Operator Overload and Task Overload Reports - Access the **Reports** menu in IMPRINT and select the **Operations Model** menu item. Highlight the Operator Workload, Operator Overload, and Task Overload Reports, and press the **Reports** button. The Operator Workload Report will provide a tabular list of the workload of each operator every time any task began or ended in the mission. It will report the Visual, Auditory, Cognitive, and Psychomotor scores. Additionally, it will tell you the number of ongoing tasks, and the score of the Overall channel, if you defined one. The Operator Overload Report will tell you the percentage of time that each operator spent in an overload condition. Finally, the Task Overload Report will tell you the number of times that each task began in an overload condition (or caused an overload condition when it began).

17. If any overload conditions existed in your mission model, you can use the **Workload Overload Reassignment** option on the **Adjust** menu to reassign some of your tasks to a Secondary operator. (Note that if you did not assign any Secondary operators, IMPRINT will give you a message that reminds you that you do not have any other operators who can accept the overload tasks). IMPRINT will automatically reassign tasks by moving through the overloaded tasks and attempting to find another operator that has access to any of the tasks that were being performed during overload. It will then reassign that task, and move to the next point of overload. Alternatively, you can manually reassign the tasks. In that case, IMPRINT will provide you with a list of all tasks that were being performed during overload and a list of all potential secondary operators and their current workload at that time. You can then select the secondary operator to whom you want the task reassigned. In this way, you can move through the points of overload, reassigning tasks as you go.

18. Review the task reassignments - In order to view the task reassignments that were made, access the **Reports** menu in IMPRINT and select the **Operations Model** menu item. Highlight the Task Reallocation Report, and press the **Reports** button. IMPRINT will display a report that lists each reassigned task, as well as lists the old and new operator assignments.

19. Re-run the analysis - In order to ensure that the task reassignments have alleviated any points of overload, you must execute the workload model again. To do this, go to the **Execute** menu, and select the **Operations Model** option. Then, repeat steps 15-18 as necessary.

Chapter 3 - Crew Workload (Advanced)

Goals and Results

IMPRINT assists you in estimating the workload associated with the performance of a new weapon system by helping you build task network workload models of each operational mission that the system will be required to accomplish. Since it is typically easier to describe the mission by breaking it into smaller "sub" functions than describing the mission as a whole, you build these models by breaking down the mission into a network of functions. Each of the functions is then further broken down into a network consisting of other functions and tasks. Next, you estimate the time it will take to perform each task, the likelihood that it will be performed accurately, and the workload associated with each task.

You can evaluate workload using either the VACP method or the Advanced Workload method. The VACP method is the simpler method and is intended to be used early in your design process. The Advanced Workload method provides a much more detailed look at the workload issue and enables you to examine the impact of workload management strategies. We recommend that you begin by using the VACP method, and if necessary, apply the Advanced Workload method as your analysis matures. When you change a mission from one method to the other, using the radio button at the bottom of the Define Mission dialog, all your data will be preserved and applied to the other analysis.

In the Advanced Workload method, IMPRINT has the capability to perform a very detailed and dynamic workload analysis, in which the task network is changed to accommodate workload levels as the model runs. While this can be a very realistic and powerful analysis, it requires that your tasks be defined explicitly and with a much greater data requirement. If you are interested in this detailed analysis, and want more information regarding the theoretical basis of the model, please refer to the documentation for this implementation of Multiple Resource Theory[1].

When you execute the simulation model of the mission, you will get results that show the total workload value over time for each operator of your system. By examining this workload graph, you can determine where the workload peaks are and which tasks were operating at that time and contributed to the peaks. These tasks are candidates for redesign, automation, or reallocation to another crew member. Additionally, all capabilities described in Chapter 1, "Crew Performance" of this Analysis Guide are available when you are developing a workload model. Therefore, in addition to providing output regarding the workload, IMPRINT can compare the minimum acceptable mission

[1] Little, R., Dahl (Archer), S.G., Plott, B., Wickens, C., Powers, J., Tillman, B., Davilla, D., Hutchins, C. "Crew Reduction in Armored Vehicles Ergonomic Study (CRAVES)," Report No. ARL-CR-80, prepared for the Army Research Laboratory, July 1993.

performance time and accuracy to the predicted performance. This will determine whether the mission has met its performance requirements.

Mental Model

In IMPRINT, the workload modeling capability can be used to examine any process that you can describe as a flow of tasks. Even though the examples in IMPRINT are all operational missions, you could actually use this capability to model a maintenance or logistics process.

You can also think of the process of developing a model, running it, and analyzing results in much the same way you would think of designing, executing, and analyzing an experiment. In this vein, you should first determine what questions you want to answer with this analysis. The workload modeling capability can answer questions such as:

- How many people do I need to perform this process within my time constraints?
- Is the current task allocation strategy balanced?
- What impact will workload have on mission performance time and accuracy?
- What impact will automation have on mission performance time and accuracy?

After you have defined the questions you are trying to answer, you should select your dependent and independent variables. Then, you should design your analysis process. After these items are determined, you will be better equipped to design a model that will be responsive to your analytical need.

It is also much easier to debug a model if you add parameters to it in an incremental fashion. In other words, you should begin by identifying the mission as a VACP mission. Lay out the network diagram, and then add task times. Next, execute the model to be sure the branching logic is running the way you expect. If everything is working in the way you intended, then you can go back and add the Advanced Workload information. Run the model again to check that your workload outputs are explainable. If you have defined workload management strategies, IMPRINT will automatically implement the workload management strategies you have chosen by assisting in removing all points of overload.

It is often difficult to find sources of data for this type of model. While IMPRINT can provide you some help in this area (e.g., libraries of existing models, inclusion of human performance micromodels), you will need to try identifying sources of data. You may be able to get some time or accuracy data from the Operational Requirements Document (ORD) of your system, test and evaluation reports of a predecessor, but similar system, or from subject matter experts on your system. Workload data are particularly difficult to get, especially for the Advanced Workload method. Your system design must be fairly mature (i.e., at least through Acquisition Milestone 1) before the information you need regarding resources and interfaces, and their assignment to specific tasks is available. After you feel you have a comfortable understanding of the crew station design, you can use benchmarked workload scales to make single task demand workload assignments.

These scales are quite descriptive and have been proven to be very reliable when used by people that are familiar with the system and the tasks. Similar assistance is available within IMPRINT when you assign conflict values. However, we do want to emphasize that the Advanced Workload method is intended to be used when your design is further along and you are attempting to answer very detailed workload questions. If your design is not mature enough to specify the controls and displays in your crew station, we recommend you use the VACP workload technique.

If data elements exist for which you do not have any existing data, we recommend that you identify the most likely and worst case values for these elements. You can then run the IMPRINT model iteratively to determine how sensitive the model results are to the variability of these data items. If the model is not very sensitive to the values in question, then you probably do not need to invest a lot of resources in finding better data. If the model is very sensitive, then you can either work to improve the quality of your data, or you can provide a decision maker with information on the most likely and worst case results.

Special Guidance

The Advanced Workload method can dynamically affect simulated mission performance through the use of Workload Management Strategies. In other words, if you have high workload during a portion of your mission, there can be an associated impact on task time, accuracy, or sequence.

If you want to perform an Advanced Workload analysis, your mission is limited to two levels of task network. The mission is composed of a network of functions. The functions are each composed of a network of tasks. You can not mix functions and tasks on the same level, and you can not have more than two levels. Additionally, because advanced workload has moderator functions of its own (under the **Crew** button), the Personnel Characteristics, Training Frequencies, and Stressors portion of IMPRINT does not affect performance of an Advanced Workload mission.

An additional issue of significance associated with the Advanced Workload missions has to do with multiple decision types. In the VACP Workload missions, when you identified a multiple decision type, you also identified the task at which the multiple paths rejoined. This is necessary so that your multiple streams combine into a single stream at the proper point in the task network. This process is discussed in detail in Chapter 3, “Using IMPRINT” in the User’s Manual. While this process is easy for the user, it does impose some restrictions on how you can lay out the task network. In the Advanced Workload method, we have removed all restrictions on the layout of the network itself. However, this increase in flexibility requires that you enter your own logic to rejoin multiple paths at the proper point in the network. This logic will typically reside in a task’s release condition, beginning effect, and ending effect. For more information, please refer to Chapter 3, “Using IMPRINT” in the IMPRINT User’s Manual.

If you want to refer to specific MOS's in your analysis, you must first go to the Define Soldiers menu option and add MOS's to your analysis. You can do this by either copying from an existing library system, or by accessing the directory of MOS's that is provided in the Define Soldiers capability. This process is described in Chapter 6, "Soldier Characteristics" in this Analysis Guide.

Data Requirements

The data in an IMPRINT Advanced Workload analysis are hierarchically organized. Below, we describe the data elements, and indicate which are required, and which are optional. You should be aware that in IMPRINT, we attempt to provide defaults for every data element that is required. Unfortunately, in the Advanced Workload analysis method, it is not possible to provide meaningful default values for every item you need. For this reason, if you begin an analysis as an Advanced Workload mission, you must enter the Operator and Crew Station Workload data (found under the **Options** menu item) before the model will run. If you attempt to run the model with incomplete information, IMPRINT will give you an error message.

Note that each data element is defined in the glossary provided in the IMPRINT User's Guide.

IMPRINT Level	Data Element	Required?	Default Value
Analysis	Name	Yes	
Analysis	Version	Yes	
Analysis	Description	No	
Mission	Name	Yes	
Mission	Time Standard	No	00:00:00.00
Mission	Time Criterion	No	0.00
Mission	Accuracy Criterion	No	0.00
Mission	Description	No	
Mission	Criterion	No	0.00
Crew Station	Interface List	Yes	
Crew Station	Resource and Interface Pairs	Yes	
Operator	Resource List	Yes	Visual, Auditory, Motor, Cognitive, Speech
Operator	Workload Management Strategies	No	A
Function	Name	Yes	Unnamed #
Function	Time Standard	No	00:00:00.00
Function	Criterion	No	0.00
Function	Branching Logic	Yes	
Task	Name	Yes	Unnamed #

Task	Time Standard	No	00:00:00.00
Task	Accuracy Standard	No	0.00 Percent Steps Correct
Task	Estimated Time	Yes	00:00:00.00
Task	Time Standard Deviation	No	00:00:00.00
Task	Time Distribution	No	Normal
Task	Estimated Accuracy	No	0.00
Task	Failure Consequences	Yes	No Effect
Task	Operator Assignments	Yes	CrewMember 1
Task	Single Task Demand Workload Ratings	Yes	
Task	Branching Logic	Yes	
Workload Channels	Conflict Values	Yes	0.0

Analysis Steps

In this document, we describe the steps required to perform an Advanced Workload analysis. You can find a detailed description of how to perform each step in Chapter 3, "Using IMPRINT" of the IMPRINT User's Guide. Additionally, please be aware that the sequence of steps provided in this document are often just one method of performing the analysis. As with most Windows products, the same operations can often be performed just as effectively in a different order.

1. Begin a new analysis - Open IMPRINT. From the **File** menu, choose **New**. You will see a dialog box in which you must enter an Analysis Name and Version. Once entered, choose **OK**.

2. Define Mission - From the **Define** menu, choose **System Mission**. You will see a dialog box that lists the missions that currently exist for your analysis.

3. Add a new mission - Use the **Add** button. Enter a mission name.

4. Enter performance standards - Highlight the mission you just added, and press the **Open** button. You will see the Mission Information dialog. If you want IMPRINT to compare the predicted performance to the required mission performance, then you must enter the mission level performance standards on this dialog. If you do not want this comparison, then you can leave all the text boxes with the default information. Set the radio button at the bottom of the dialog to **Advanced Workload Analysis**.

5. Enter the list of crew members for your system - Click on the **Crew** button on the Mission Information dialog. Enter the names of the crew members or automation devices that will be assigned to perform the tasks in your mission. If desired, you can also use this interface to set some performance moderators for task time and accuracy based on operator experience, fatigue, and aptitude. Click **OK** to return to the Mission Information dialog.

6. Go to the task network diagram - Press the **Functions + Tasks** button to get to the list of functions and tasks at the top level of your mission. You can enter the functions and tasks using these lists, or you can proceed to the network diagram and use the drawing space to draw your network.

7. Draw a network to show task sequence - Press the **Network Diagram** button. The network diagram will be blank except for the start and end functions that are required in each mission. Use the tool bar and select the **Function** or **Task tool**. Click on the network workspace to place the new node. Use the tool bar and select the **Path** tool. Draw paths between your nodes to show the sequence of the tasks and functions. For more detailed information on what each tool on the tool bar is used for, and how to navigate around the network, access IMPRINT on-line help, or see the IMPRINT User's Guide. Remember that in an Advanced Workload mission, you are limited to two levels of the task network. You must have only functions at the top level and only tasks at the second level. You can not mix functions and tasks in the same level.

8. Enter task data - Double click on each task node to view the task information dialog. You will notice that this dialog has tabs along the bottom edge that enable you to view data that are attached to each task in your mission. For this example, we are interested in information on the **Timing and Accuracy** tab and on the **Crew Assgn** tab. Workload assignments will be done later, using dialogs that are accessed under the **Options** menu.

9. Enter time and accuracy predictions - If you want IMPRINT to compare predicted performance to required performance at the task level, you must enter the Time and Accuracy Standards and Criteria. In particular, we recommend that you enter the accuracy standard and measure so that you will document what you mean by "accurate performance" on this task. This will be helpful to other people who review your mission and it can also be helpful to you when you attempt to estimate the probability of task success. It is important that you enter the **Estimated Task Time** and **Estimated Task Accuracy** data elements. These data elements are used to drive the mission simulation model. You can use the **Previous** and **Next** buttons to move through the tasks within each function of your mission. Enter these data for every task in your mission.

10. Assign operators to your tasks - Click on the **Crew Assgn** tab for each task. Use the spreadsheet to assign primary operators for each of your tasks. Assign contingency operators for any tasks in which other crewmembers have access to the controls and displays needed to perform the tasks and for which they have the training and decision authority to perform the task. You will notice that all the tasks are listed, and you do not need the **Previous** and **Next** buttons to move through the tasks within each function of your mission. You can exit out of the network diagram by using the **Close** box on the network drawing window. Use the **OK** buttons to return to the top level of the mission. IMPRINT will prompt you to save the network diagram.

11. Save your mission - Use the **Save** command on the **File** menu to save your data. We strongly recommend that you use this command often during your IMPRINT session.

12. Enter Workload Management Strategies - Access the **Options** menu, and choose the **Workload Management Strategies** menu item. This capability enables you to define the workload threshold for each operator, and how each operator will respond when they hit a point of high workload. The default workload management strategy indicates that the operators will continue doing all tasks at the same time. However, as you can see from the interface, you can set a workload management strategy for an operator so that it will reallocate tasks to another crewmember, dump tasks, or serialize tasks. We suggest that you first run your Advanced Mission with the default workload management strategy. After you are convinced that your model is running correctly, you can begin to implement other strategies and study their effects.

13. Define Resource and Interfaces - The process of defining the workload imposed by each task in the mission is rather extensive for Advanced Workload. There are five steps to the process and they can all be found under the **Workload and Crewstation Parameters** item on the **Options** menu. Access the first step by selecting **Define Resources and Interfaces** from the cascading menu. This dialog shows a list of human resources (similar to VACP channels) on the left side of the screen. This list will contain five default resources (auditory, visual, motor, cognitive, speech). You can add up to five more to this list. The list on the right side of the screen is the list of controls and displays in your crew station. Use the **Add** button to add your interfaces to the list. We recommend that you define your interfaces at a high level to begin this analysis. Later, if necessary, you can break them into more detail. You will see in the upcoming interfaces that the number of interfaces you enter is a multiplier in the amount of data you must enter in subsequent screens. Examples of resources are "Control Stick" and "Visual Display." When you have entered all your resources, use the **OK** button to exit.

14. Define Resource/Interface Channels - Access the second step on the cascading menu under the **Workload and Crewstation Parameters** item on the **Options** menu. This step is called **Define Resources/Interface Channels.** For each crew member in the mission, you will form pairs between the resources and interfaces you identified under Define Resources and Interfaces. This screen appears as a large matrix with interfaces down the first column and the resources across the top row. The cells are shown as boxes. The spreadsheet scrolls to the left and right and up and down if necessary. Click on the cell in the row and column corresponding to the interface name and the resource name that will be used together (e.g., Visual and Visual Display). IMPRINT will change marked cells to unmarked cells and vice versa. You can assign each interface up to five resources by marking cells in the spreadsheet. For every interface that the selected crew member utilizes in performing either primary or contingency tasks you should assign at least one resource. Once you have assigned

the resource interface pairs for one operator you can select another operator to assign channels using the **Next** and **Previous** buttons.

15. Assign Resource/Interface Channels to Tasks - Access the third step on the cascading menu under the **Workload and Crewstation Parameters** item on the **Options** menu. This step is called **Assign Resources/Interface Channels to Tasks.** For each crewmember in the mission you will identify the resource/interface channels that are used in performing each task. Each task may require more than one resource/interface channel. Your entries will be used to structure the multiple resource theory workload analysis performed by IMPRINT during model execution. The window displays a spreadsheet interface with task names displayed down the left most column and resource/interface channels displayed across the top. The tasks are grouped by function and the channels are grouped by resource. Only those tasks that were assigned to the crew member as either a primary task or a contingency task are displayed. The cells are shown as check boxes. Any previous task and channel assignments are indicated by check marks in the cells. The spreadsheet scrolls left and right and up and down if necessary. To mark or unmark a channel as being utilized when the operator is performing a task, click on the cell in the row and column corresponding to the task name and the channel name, respectively. IMPRINT will change an unassigned task/channel to an assigned task/channel and vice versa. Each task can be assigned to up to five resource/interface channels. Once every task has been assigned to at least one resource/interface channel, you can select another operator using the **Prev** and **Next** buttons.

16. Assign Single Task Demands - Access the fourth step on the cascading menu under the **Workload and Crewstation Parameters** item on the **Options** menu. This step is called **Assign Single Task Demands.** For each crew member in the mission you will enter single task demand values. These values will be used to compute the first order workload components during model execution. The values should indicate the relative demand on each channel when performing a task. The window displays a spreadsheet with the task names displayed down the left most column and the resource/interface channels displayed across the top. The tasks are grouped by function and the channels are grouped by resource. Only those tasks that were assigned to the crew member as either a primary or contingency task are displayed. Cells that require a demand value to be entered are shown as boxes. Any demand values previously entered are displayed in the cells. The default demand value is zero. The spreadsheet scrolls left and right and up and down if necessary. To enter a demand value automatically, double click the mouse in the cell that corresponds to the desired task and channel. Note: Automatic entry can only be used if the channel involves one of the five default resources (visual, auditory, motor, speech, or cognitive). If you defined resources in addition to the default resources, you will not have the automatic entry option, you will have to manually enter the demand value. In automatic mode, IMPRINT recommends a demand value. In manual mode, you must enter a demand value. To enter a demand value manually, click once in the demand field and use the numeric, backspace, and delete keys to manually enter a

value. Once you have assigned demand values for all operators, either manually or automatically, click on the **OK** button.

17. Assign Channel Conflict Values - Access the final step on the cascading menu under the **Workload and Crewstation Parameters** item on the **Options** menu. This step is called **Assign Channel Conflict Values.** For each crew member in the mission you need to enter channel conflict values. These values will be used to compute the second and third order workload components during model execution. Conflict values range from 0.0 to 1.0. A conflict value of 0.0 means that the two channels do not interfere with each other at all. A conflict value of 1.0 means that the two channels cannot be utilized at the same time. IMPRINT has two modes available to you for assigning the conflict values. In automatic mode, IMPRINT recommends a conflict value. In manual mode, you enter a value from the keyboard. Automatic mode is only available for channels that utilize one of the five basic resources (visual, auditory, motor, speech, and cognitive). Channels that utilize other resources must have conflict values manually entered. The Assign Channel Conflict Values window displays a spreadsheet with the resource/interface channels displayed both down the left column and across the top. The channels are grouped by resource. The interface names listed down the left column are displayed in boxes if they are potential candidates for automatic entry. The cells in the spreadsheet are displayed as boxes. Any previously defined conflict values are displayed in the cells. The default conflict value is 0.0. To enter a conflict value in automatic mode, click on a interface name in the left column that is surrounded by a box. To manually enter a conflict value, click on a cell in the spreadsheet.

18. Execute the Operations Mission - Access the Execute menu, and select the **Operations Model** option. Notice that you can vary the number of times you want to run the mission model and the random number seed. Press the **Run Model** button. When the model is finished (it should run very quickly), you will be reminded that you can access the results using the **Reports** menu.

19. View Operator Workload and Overload Reports - Access the **Reports** menu in IMPRINT and select the **Operations Model** menu item. Highlight the Operator Workload and Overload Reports, and press the **Reports** button. The Operator Workload Report will provide a tabular list of each operator workload every time any task began or ended in the mission. The Operator Overload Report will list every time during the mission that any operator was in overload. It provides details of each component of the workload score and also indicates which functions and tasks were executing at the time that overload occurred. There are several other reports that contain different aspects of the workload results, but these two reports are the most indicative of the amount of overload that your operators experienced.

20. If any overload conditions existed in your mission model, you can take several different paths to resolve these overloads. You can either return to the tasks themselves and manually reassign them to different operators, you can change the

mission network to represent a change in the process, you can return to the Workload Management Strategies and select a strategy that reallocates tasks automatically, or you can redesign the way the task is performed (either by adjusting the resources and interfaces that are used, or through changing the single task demands). This process of alleviating overload conditions typically requires an iterative approach that consists of making changes, and repeating the execution of the model in order to study the effect that the changes had on overall mission performance. We recommend that you save the results of your work often, and use the Duplicate Mission capability to make copies of your mission whenever you have reached a point in your iterative process that you would like to document.

We would like to emphasize that the Advanced Workload capability in IMPRINT is most useful for analyses in which the system design is reasonably mature. We also recommend that you familiarize yourself with the Multiple Resource Theory of Workload[2] prior to beginning this type of analysis.

[2] Wickens, C.D., Yeh, Y-Y, 1986, A Multiple Resource Model of Workload Prediction and Assessment. In Proceedings of the IEEE Conference on Systems, Man, and Cybernetics (Atlanta, Georgia).

Chapter 4 - Maintenance Manpower Requirements

Goals and Results

One of the primary objectives of the Define Equipment module in IMPRINT is to help you estimate maintenance man-hour requirements for your system. This module lets you enter parameters that control such items as the maintenance manpower pools, the spare availability and the combat damage potential. These parameters, coupled with a mission schedule and the data describing the maintenance actions that your system may need, are combined in a stochastic maintenance simulation. The primary purpose of the simulation is to predict the maintenance man-hours required to attain an acceptable system availability.

The results of the simulation include maintenance manpower requirements by MOS and skill level as well as by maintenance organization level. The results are provided at a summary level, as well as on a daily level for the length of the simulation run. As a result of this analysis, other results such as predicted Reliability, Availability, and Maintainability (RAM) of your system, are also generated and are available.

Mental Model

The maintenance analysis capability consists of a “canned” simulation model that is driven by data you enter in IMPRINT. In the following paragraphs, we provide a very general description of how the model works. Details as to how the process works can be found in Chapter 5, “Overview of the IMPRINT Maintenance Model,” in the IMPRINT User’s Manual.

The Maintenance Analysis model predicts manpower requirements by simulating the maintenance requirements of a unit as the systems are sent out on missions, then to maintenance (as required), and then placed back into a pool of available systems. This process repeats for the duration of your scenario. There are, of course, a number of complexities involved in this process. For instance, when a system comes into maintenance, it is prioritized and scheduled for repair based on the pools of maintainers with specific specialties available in the particular maintenance level needed. Therefore, if you have very tightly constrained manpower pools, the maintenance will take longer, since fewer repairs can be performed in parallel. This will have an adverse effect on the system availability. If the system is not available to be sent out on other missions, it will actually accrue less usage because it is in maintenance, rather than performing missions on the battlefield. Oddly enough, this will result in less maintenance since the components are not accruing as much wear and tear.

Other issues that affect the maintenance system include spare availability, combat damage, maintenance shifting, and the criticality of individual component failures. In the Analysis Steps provided below, we discuss some of these issues. If you are interested in the details of how the model works, please refer to Chapter 3, "Using IMPRINT" in the User's Manual.

You can also think of the process of developing a maintenance analysis, running it, and analyzing results in much the same way you would think of designing, executing, and analyzing an experiment. In this vein, you should first determine what questions you want to answer with this analysis. The maintenance manpower analysis capability can answer questions such as:

- How many people of each specialty do I need in order to meet the system availability requirement?
- Which pieces of equipment (i.e., subsystems) are the high drivers for maintenance?
- How should each organizational level be staffed?
- How sensitive is my maintenance manpower requirement to the failure rates of individual components?

After you have defined the questions you are trying to answer, you should select your dependent and independent variables. Then, you should design your analysis process. After these items are determined, you will be better equipped to conduct a study that will be responsive to your analytical need.

To conduct an IMPRINT analysis of the maintenance man-hour requirements to support a particular system, you will need to perform three basic activities:

1. You will need to describe the maintenance requirements for the system by specifying the following information for each component system:
   a) how often the component needs to be maintained (i.e., rounds fired, time operated)
   b) the type of maintenance task that needs to be performed (remove & replace, repair, inspect, troubleshoot, etc.)
   c) the type and number of maintainers that are needed to perform the maintenance task
   d) how long it will take to perform each maintenance task
   e) whether the maintenance is scheduled or unscheduled
   f) the maintenance organizational type at which the task needs to be performed (e.g., Organization (ORG), Direct Support (DS), General Support(GS))
   g) whether a contact team could perform the maintenance

2. The next activity you will perform will be to build a simulation scenario defining the conditions that will be used for the system you are modeling, and the amount of usage the components in each system will incur. System usage and probabilities for combat damage will be determined by missions that you will define for the scenario. Each scenario can contain multiple missions.

3. The final activity you will perform in preparation for the IMPRINT maintenance simulation run will be to define the unit configuration and support parameters for each scenario. These parameters include:
   a) Operational crew (per system) - This is an optional parameter, and the information defaults to an empty set of operational crew members.
   b) Maintenance shift manning (size, type) - This parameter defaults to the minimum possible shift manning, as well as one shift per day that is eight hours long. IMPRINT calculates the minimum shift manning by examining each maintenance task to find the minimum number of people in each specialty that will enable any given task to be performed.
   c) Spare parts (availability, wait times) - This is also an optional parameter and is specified at the subsystem level. This parameter defaults to 100% availability, and a zero wait time.

If you are using IMPRINT to evaluate the maintenance requirements for a proposed new system in the acquisition cycle, you can enter the component maintenance parameters from scratch or from a system design. However, it is more likely that you will begin by copying maintenance parameters from a similar library system and then modifying existing components and/or adding new components to reflect the system you are trying to evaluate. If you are using IMPRINT for a different purpose, such as unit design, you may want to simply copy a library system and use it as is. You can use the same components and maintenance actions and modify only the types of maintainers, maintenance levels or other parameters for the existing components.

You may be able to get some maintenance task data from the system contractor. Often, contractors are required to deliver Logistics Support Analysis Records, also referred to as "LSA data." IMPRINT will import these data, and automatically generate the database of maintenance task parameters for you if you have access to LSA data. For more information on this capability, refer to Chapter 3, "Using IMPRINT" in the IMPRINT User's Manual.

As mentioned above, the maintenance analysis also requires a mission schedule, or operational profile. This information is used to determine the intensity of the scenario. The intensity, or operating tempo, drives the distance the system travels, the number of rounds each weapon system fires, and the number of operating hours that are accrued during each day of the scenario. This information, in turn, controls when the individual components will fail. Often, data that help define the operational profile are available in the ORD of your system, test and evaluation reports of a predecessor, but similar system, or from subject matter experts on your system. If data elements exist for which you do not have any existing data, we recommend that you identify the most likely and worst case values for these elements. You can then run the IMPRINT model iteratively to determine how sensitive the maintenance manpower results are to the variability of these data items. If the results are not very sensitive to the values in question, then you probably do not need to invest a lot of resources in finding better data. If the results are very sensitive, then you can either work to improve the quality of your data, or you can provide a decision maker with information on the most likely and worst case results.

Special Guidance

There are a few limitations in the maintenance manpower analysis capability that will affect your results. You should first be aware that the model assumes that all Unit level maintenance is performed “On Equipment.” This means that the system will not be considered “available” to be sent out on other missions until all Unit level maintenance is completed. You can determine whether Direct Support (DS) (or second level) maintenance is performed either “On Equipment” or “Off Equipment” for each individual maintenance action. The model assumes that all General Support (GS) (or third level) maintenance is performed “Off Equipment.” Off Equipment maintenance means that the system will be considered available before the repairs are complete because it is modeling maintenance as though the component has been removed from the system for repair.

An additional assumption made in the model is that the model prioritizes maintenance so that the system with the smallest amount of total repair time is repaired first. All Unit level maintenance must be completed prior to beginning any DS level maintenance. Similarly, all DS level maintenance must be completed prior to beginning any GS level maintenance.

Spare part availability is only considered for Remove and Replace Repair Tasks that are being performed at the Unit Level. All other repairs are performed independent of the spare parts availability data.

One very important aspect of the maintenance manpower analysis capability is the concept of failure clocks. IMPRINT’s maintenance model is very high fidelity. Each component of each system in your analysis has its own failure clock. Failures are predicted by individually comparing the accrued usage on each component to an exponential statistical distribution, with a mean that is equal to the component’s failure clock. This provides a realistic estimation of maintenance requirements throughout the scenario by simulating a failure time that is randomly distributed.

Data Requirements

The data in an IMPRINT maintenance analysis are hierarchically organized. The equipment is composed of subsystems. Subsystems are constructed with components. Each component has one or more repair tasks. Also each equipment definition is associated with at least one scenario. Scenarios are composed of mission segments.

Below, we describe the data elements, and indicate which are required, and which are optional. You should be aware that in IMPRINT, we attempt to provide defaults for every data element that is required. For this reason, even though a data element is “required” you may not actually have to enter it yourself.

Note that each data element is defined in the glossary provided in the IMPRINT User's Guide.

IMPRINT Level	Data Element	Required?	Default Value
Analysis	Name	Yes	
Analysis	Version	Yes	
Analysis	Description	No	
Subsystem	Name	Yes	
Subsystem	Equipment Type	Yes	Mobility
Component	Name	Yes	
Repair Task	Name	Yes	
Repair Task	Mean Operational Unit Between Failure	Yes	999999
Repair Task	Mean Time to Repair (MTTR)	Yes	0.00
Repair Task	MTTR Standard Deviation	No	0.00
Repair Task	MTTR Distribution	No	Normal
Repair Task	MOS and Number	Yes	
Repair Task	Organizational Level	Yes	ORG
Repair Task	Contact Team	No	No
Repair Task	Probability of Abort	Yes	0.00
Scenario	Name	Yes	
Scenario	Shift Manning	Yes	999
Scenario	Travel Times	No	0.00
Scenario	Spare Availability	No	100.0
Scenario	Number of Systems	Yes	1
Scenario	Length	Yes	1 Day
Segment	Name	Yes	
Segment	Start Time	Yes	00:00:00.00
Segment	Start Day	Yes	1
Segment	Cancellation Time	No	00:00:00.00
Segment	Duration	Yes	04:00:00.00
Segment	Priority	No	0
Segment	Minimum Number of Systems	Yes	1
Segment	Maximum Number of Systems	Yes	1
Segment	Time Between Departure Groups	No	00:00:00.00
Segment	Number per Departure Group	No	0
Segment	Repeating Data	No	
Segment	Consumables	Yes	0
Segment	Combat Damage	No	0.00

Combat damage estimates are particularly difficult to make, and therefore deserve special discussion. The primary sources of combat data are the U.S. Army Concepts Analysis

Agency (CAA), the U.S. Army Materiel and Systems Analysis Activity (AMSAA), the U.S. Army Training and Doctrine Command (TRADOC), and Combined Arms subject matter experts.

Analysis Steps

In this document, we describe the steps required to perform a maintenance manpower analysis. You can find a detailed description of how to perform each step in Chapter 3, "Using IMPRINT," of the IMPRINT User's Guide. Additionally, please be aware that the sequence of steps provided in this document are often just one method of performing the analysis. As with most Windows products, the same operations can often be performed just as effectively in a different order.

1. Begin a new analysis - Open IMPRINT. From the **File** menu, choose **New**. You will see a dialog box in which you must enter an Analysis Name and Version. Once entered, choose **OK**.

2. Define Soldiers - Begin by entering the MOS's for the soldiers that will be assigned to your new system. From the **Define** menu, choose **Soldiers**. Use the **Add** button to enter a list of MOS's that will maintain your system. Click on the **OK** button when you are finished.

3. Define Mission - From the **Define** menu, choose **Equipment**. You will see a dialog box that contains your Analysis Name, Version and Description. Click on the **Evaluate Design** button. You will see a dialog that contains a list of the subsystems within your system.

4. Add a new subsystem - Use the **Add** button. Enter a subsystem name. Use the combo box in the second column to indicate whether this subsystem is an Armaments, Mobility, or Other type. This indication determines how usage will be accrued to the components in the subsystem. Armaments subsystems accrue usage (and, therefore, fail) based on the number of rounds fired. Mobility subsystems accrue usage based on the distance traveled. Other subsystems accrue usage based on operating time. To begin entering components for your subsystem, select the subsystem and Click on the **Open** button.

5. Add the components in your new subsystem - Use the **Add** button. Enter a component name. To begin adding repair tasks for your component, select the component, and click on the **List Repair Tasks** button.

6. Enter repair task data - The component you selected will be listed at the top of the dialog box. Use the **Add** button to begin entering the repair tasks that will need to be performed on this component. You can choose from a set of task names. As you enter repair tasks, each repair task will be added to the spreadsheet. You can then move across the columns of the spreadsheet and set the maintenance parameters. The first and second column will be filled in for you based on the repair task that you

chose. The third column is the **organizational level** at which the task will be performed. The next six columns are used to enter the **MOS**, **skill level**, and **the crew size** needed to perform the task. Notice that you enter two different MOS's (or the same MOS with two different skill levels). IMPRINT will make both these specialties busy for the entire length of the repair task. So if you have a repair task that doesn't require the attention of both MOS' for the entire length, you should break it into two tasks. The next column is the Mean Operational Unit Between Failure (**MOUBF**). This is the number that IMPRINT uses to predict when the repair task will be needed. The MOUBF is more typically called a Mean Time Between Failure (MTBF) in maintenance modeling literature, and is the inverse of the failure rate. The next three columns compose the specification of how long it will take to perform the maintenance task. The first of these columns is the Mean Time to Repair (**MTTR**). This value is in hours. This is a value representing the average time it takes to perform this maintenance action. This value and the standard deviation for the repair time (**SD MTTR**) are used to generate a simulated time for this maintenance action from the statistical **distribution** you choose in the next column. The final two columns include the probability of whether this repair task will cause an ongoing mission to abort (**Abort %**) and an indication of whether this task could be performed by a **contact team**. Enter the repair data for each task in for your component. You can use the **Next** and **Previous** buttons to move through all the components in your subsystem. Click on the **OK** button when you have finished.

7. Enter the remainder of your equipment data - Repeat steps 3-5 until you have entered a full description of your equipment. Once you have completed these steps, most of your work is done. You can exercise this equipment description against a wide variety of different scenarios with very little effort.

8. Save your results - Use either the Save tool on the IMPRINT tool bar or the Save command under the File menu to save your results. We recommend that you save often throughout your IMPRINT session.

9. Enter a scenario - Return to the Evaluate Design dialog, and click on the **Scenarios** button. This will open a list of existing scenarios. Use the **Add** button to add a new scenario.

10. Enter scenario data - Highlight a scenario name and click on the **Open** button. From this new dialog, you can decompose your scenario into segments, as well as enter Maintenance Crew Manning data, Travel Time data, and Spare data.

11. Decompose the scenario into segments - Click on the **Segments** button. This will open a dialog with a list of the mission segments. Use the **Add** button to add segments.

12. Enter the mission segment data - Highlight a segment and click on the **Operational Profile** button. This will open a dialog that contains all of the data items associated

with a mission segment. Starting at the top of the dialog, enter the segment start time and day. If you want the mission segment to be scheduled for departure at 0800 on the first day of the scenario, then these values would be 08:00:00 and 1. Next, enter the Cancellation time. If the segment has not departed within this amount of time from the Departure Time, then the segment will be canceled. The next data item is the segment duration. The data item following that is the segment priority. This is used if two segments are competing for a limited number of available systems. The highest priority segment will be filled first. The next two data items are the minimum and maximum number of systems needed for this segment. The segment will not be canceled if the minimum number of systems are available prior to the departure time plus the cancellation time. If there are enough systems available, the segment will be filled with the maximum number of systems. The next two elements are the number per departure group and the time between departures. These two data items enable you to stagger the departures of your systems. You will also notice that you can set this mission segment to repeat periodically throughout the scenario.

13. Enter Combat Damage parameters - Click on the **Combat** button to enter the likelihood that your system will sustain combat damage during this segment, and if so, whether the system will be destroyed. If desired, you can enter the amount of time it will take to repair combat damage, or if the system is destroyed, the amount of time it will take before the system can be replaced in the Unit's inventory. If the system undergoes repair due to combat damage, that repair time is NOT attributed to a specific subsystem or MOS. Rather, it is indicated separately in the Combat Damage Report. It will, however, affect system availability. Click on the **OK** button to return to the segment dialog.

14. Enter Consumable data - Click on the **Consumables** button to enter the amount of rounds your system will fire and the distance it will travel during this mission segment. Also, you can enter the time needed to prepare the system for the segment. This is called the Load Time. This time will only delay the beginning of the segment. It will not affect failure rates. Click on the **OK** button to return to the segment dialog.

15. When you have finished entering these data, you can use the **Next** and **Previous** buttons to move through the rest of your segments. Use the **OK** button to exit back to the Scenarios dialog.

16. Enter Maintenance Crew data - Click on the **Maintenance Crew** button on the Scenarios dialog. In this dialog, you can enter the shifting information and the maintenance crew manning information if you want to run your maintenance model with a limited maintenance crew. We recommend that the first time you run your maintenance model, you run it in an unconstrained mode. This will result in a maintenance analysis where system availability is maximized (because there will always be an unlimited number of soldiers available to maintain the system). Then, after you have satisfied yourself that these results are reasonable, you should return to

this screen and enter constrained maintenance crews in order to more realistically predict maintenance. Click on the **OK** button to return to the Scenarios dialog.

17. Save your results - Use either the **Save** tool on the IMPRINT tool bar or the **Save** command under the **File** menu to save your results. As mentioned above, we recommend that you save often throughout your IMPRINT session.

18. Execute the maintenance model - Access the **Execute** menu, and select the **Maintenance Model** option. Notice that you can vary the length of the run and the random number seed. You also must enter the number of systems that you want to include in your maintenance model. Remember to include enough systems so that you can meet the minimum number on your segments. Finally, notice that there is a check box on this screen to indicate whether you want to turn the Crew Limits on. If you have entered maintenance crew sizes, yet you want to run the maintenance model in an unconstrained mode, just make sure that you "uncheck" this box. Press the **Run Model** button. When the model is finished, you will be reminded that you can access the results using the **Reports** menu.

19. View Maintenance Summary, Headcount Frequency, and Maintenance Man-hour Reports - Access the **Reports** menu in IMPRINT and select the **Maintenance Model** menu item. Highlight the Maintenance Summary, Headcount Frequency, and Maintenance Man-hour Reports, and press the **Reports** button. The Maintenance Summary Report will include the total number of operational hours that were modeled in your scenario, as well as the sum of the preventive and corrective maintenance man-hours expended during the scenario. The Headcount Frequency report Report is a list of the frequency that different crew sizes were used for each MOS at each skill level within each organizational level. If you ran your model in an unconstrained mode, you can use this report to help you decide on reasonable constraints for each of your maintainers. This report provides a measure of MOS utilization. It illustrates the frequency with which different numbers of people in each MOS were used. The highest bin for which a > 0% utilization is shown will never exceed the shift manning levels you set for that MOS and that organizational level type. Additionally, if the highest bin shown has a relatively high frequency, as in the example of 20% of the time three people being used, then it is possible that you have constrained this MOS so tightly that it is reducing system availability. Finally, the Maintenance Man-hour Report lists the number of man-hours actually expended by each MOS and skill level at each organizational level. This report will help you identify the high driver maintainers for your system.

20. Next, you can return to the maintenance manning dialog to change the distribution of maintenance manpower in your organization.

21. Rerun the analysis - In order to evaluate the impact of the modified manning, you must rerun the analysis and review the reports in order to ensure that your system availability is still acceptable.

Chapter 5 - System Reliability, Availability and Maintainability

Goals and Results

One of the primary objectives of the Define Equipment module in IMPRINT is to help you estimate your system's reliability, availability, and maintainability (RAM). This module lets you enter parameters that control such items as the maintenance manpower pools, the spare availability and the combat damage potential. These parameters coupled with a mission schedule and the data describing the maintenance actions that your system may need are combined in a stochastic maintenance simulation. The results of this analysis are a variety of system-level RAM measures. These measures are also broken down into more detail so that you can identify the high driver subsystems of your systems. Also, as a result of this analysis, other measures such as the maintenance manpower requirements by MOS (specialty), skill level, and maintenance level are also generated and are available.

Mental Model

The maintenance analysis capability consists of a “canned” simulation model that is driven by data you enter in IMPRINT. In the following paragraphs, we provide a very general description of how the model works. Details as to how the process works can be found in Chapter 5, “Overview of the IMPRINT Maintenance Model” in the IMPRINT User’s Manual.

The Maintenance Analysis model predicts system RAM by simulating the maintenance requirements of a unit as the systems are sent out on missions, then to maintenance (as required), and then placed back into a pool of available systems. This process repeats for the duration of your scenario. There are, of course, a number of complexities involved in this process. For instance, when a system comes into maintenance, it is prioritized and scheduled for repair based on the pools of maintainers with specific specialties available in the needed maintenance level. Therefore, if you have very tightly constrained manpower pools, the maintenance will take longer, since fewer repairs can be performed in parallel. This will have an adverse effect on the system availability. If the system is not available to be sent out on other missions, it will actually accrue less usage (because it is in maintenance, rather than performing missions on the battlefield). Oddly enough, this will result in less maintenance, since the components are not accruing as much wear and tear.

Other issues that affect the maintenance system include spare availability, combat damage, maintenance shifting, and the criticality of individual component failures. In the Analysis Steps provided below, we discuss some of these issues. If you are interested in the details of how the model works, please refer to Chapter 5, “Overview of the IMPRINT Maintenance Model” in the User’s Manual.

You can think of the process of developing a maintenance analysis, running it, and analyzing results in much the same way you would think of designing, executing, and analyzing an experiment. In this vein, you should first determine what questions you want to answer with this analysis. The maintenance manpower analysis capability can answer questions such as:

- How many people of each specialty do I need in order to meet the system availability requirement?
- Which pieces of equipment (i.e., subsystems) are the high drivers for maintenance?
- How does the system availability vary over the duration of a scenario?

After you have defined the questions you are trying to answer, you should select your dependent and independent variables. Then, you should design your analysis process. After these items are determined, you will be better equipped to conduct a study that will be responsive to your analytical needs.

To conduct an IMPRINT analysis of the system RAM, you will need to perform three basic activities:

1. First, you will need to describe the maintenance requirements for the system by specifying the following information for each component system:
   a) how often the component needs to be maintained (i.e., rounds fired, time operated)
   b) the type of maintenance task that needs to be performed (remove & replace, repair, inspect, troubleshoot, etc.)
   c) the type and number of maintainers that are needed to perform the maintenance task
   d) how long it will take to perform each maintenance task
   e) whether the maintenance is scheduled or unscheduled
   f) the maintenance organizational type at which the task needs to be performed (e.g., ORG, DS, GS)
   g) whether a contact team could perform the maintenance

2. The next activity that you will perform will be to build a simulation scenario that will define the conditions under which the system you are modeling will be used and the amount of usage the components in each system will incur. System usage and probabilities for combat damage will be determined by missions that you will define for the scenario. Each scenario can contain multiple missions.

3. The final activity you will perform to prepare for the IMPRINT maintenance simulation run will be to define the unit configuration and support parameters for each scenario. These parameters include:
   a) Operational crew (per system) - This is an optional parameter, and the information defaults to an empty set of operational crew members.
   b) Maintenance shift manning (size, type) - This parameter defaults to the minimum possible shift manning, as well as one shift per day that is eight

hours long. IMPRINT calculates the minimum shift manning by examining each maintenance task to find the minimum number of people in each specialty that will enable any given task to be performed.

c) Spare parts (availability, wait times) - This is also an optional parameter and is specified at the subsystem level. This parameter defaults to 100% availability, and a zero wait time.

If you are using IMPRINT to evaluate the RAM for a proposed new system in the acquisition cycle, you can enter the component maintenance parameters from scratch or from a system design. However, it is more likely that you will begin by copying maintenance parameters from a similar library system and then modifying existing components and/or adding new components to reflect the system you are trying to evaluate. If you are using IMPRINT for a different purpose, such as unit design, you may want to simply copy a library system. Use the same components and maintenance actions and modify only the types of maintainers, maintenance levels or other parameters for the existing components.

You may be able to get some maintenance task data from the system contractor. Often, contractors are required to deliver Logistics Support Analysis Records, also referred to as "LSA data." IMPRINT will import these data, and automatically generate the database of maintenance task parameters for you if you have access to LSA data. For more information on this capability, refer to the IMPRINT User's Manual.

As mentioned above, the maintenance analysis also requires a mission schedule, or operational profile. This information is used to determine the intensity of the scenario. The intensity, or operating tempo, drives the distance the system travels, the number of rounds each weapon system fires, and the number of operating hours that are accrued during each day of the scenario. This information, in turn, controls when the individual components will fail. Often, data that help define the operational profile are available in the Operational Requirements Document (ORD) of your system, test and evaluation reports of a predecessor, but similar system, or from subject matter experts on your system. If data elements exist for which you do not have any existing data, we recommend that you identify the most likely and worst case values for these elements. You can then run the IMPRINT model iteratively to determine how sensitive the maintenance manpower results are to the variability of these data items. If the results are not very sensitive to the values in question, then you probably do not need to invest a lot of resources in finding better data. If the results are very sensitive, then you can either work to improve the quality of your data, or you can provide a decision maker with information on the most likely and worst case results.

Special Guidance

There are a few limitations in the system RAM analysis capability that will affect your results. First, you should be aware that the model assumes that all Unit level maintenance is performed "On Equipment." This means that the system will not be considered "available" to be sent out on other missions until all Unit level maintenance is completed.

DS and GS (or second and third level maintenance) are assumed to be performed "Off Equipment." This means that the system will be considered available before the repairs are complete because it is modeling maintenance as though the component has been removed from the system for repair.

An additional assumption of the model is that maintenance is prioritized so that the system with the smallest amount of total repair time is repaired first. Also, all Unit level maintenance must be completed prior to beginning any DS level maintenance. Similarly, all DS level maintenance must be completed prior to beginning any GS level maintenance.

Spare part availability is only considered for Remove and Replace Repair Tasks that are being performed at the Unit Level. All other repairs are performed independent of the spare parts availability data.

One very important aspect of the system RAM analysis capability is the concept of failure clocks. IMPRINT's maintenance model is very high fidelity. Each component of each system in your analysis has its own failure clock. Failures are predicted by individually comparing the accrued usage on each component to its failure clock. This provides a realistic estimation of maintenance requirements throughout the scenario.

Data Requirements

The data in an IMPRINT RAM analysis are hierarchically organized. The equipment is composed of subsystems. Subsystems are composed of components. Each component has one or more repair tasks. Also each equipment definition is associated with at least one scenario. Scenarios are composed of mission segments.

Below, we describe the data elements, and indicate which are required, and which are optional. You should be aware that in IMPRINT, we attempt to provide defaults for every data element that is required. For this reason, even though a data element is "required" you may not actually have to enter it yourself.

Note that each data element is defined in the glossary that is provided in the IMPRINT User's Guide.

IMPRINT Level	Data Element	Required?	Default Value
Analysis	Name	Yes	
Analysis	Version	Yes	
Analysis	Description	No	
Subsystem	Name	Yes	
Subsystem	Equipment Type	Yes	Mobility
Component	Name	Yes	
Repair Task	Name	Yes	
Repair Task	Mean Operational Unit Between	Yes	999999

	Failure		
Repair Task	Mean Time to Repair (MTTR)	Yes	0.00
Repair Task	MTTR Standard Deviation	No	0.00
Repair Task	MTTR Distribution	No	Normal
Repair Task	MOS and Number	Yes	
Repair Task	Organizational Level	Yes	ORG
Repair Task	Contact Team	No	No
Repair Task	Probability of Abort	Yes	0.00
Scenario	Name	Yes	
Scenario	Shift Manning	Yes	999
Scenario	Travel Times	No	0.00
Scenario	Spare Availability	No	100.0
Scenario	Number of Systems	Yes	1
Scenario	Length	Yes	1 Day
Segment	Name	Yes	
Segment	Start Time	Yes	00:00:00.00
Segment	Start Day	Yes	1
Segment	Cancellation Time	No	00:00:00.00
Segment	Duration	Yes	04:00:00.00
Segment	Priority	No	0
Segment	Minimum Number of Systems	Yes	1
Segment	Maximum Number of Systems	Yes	1
Segment	Time Between Departure Groups	No	00:00:00.00
Segment	Number per Departure Group	No	0
Segment	Repeating Data	No	
Segment	Consumables	Yes	0
Segment	Combat Damage	No	0.00

Analysis Steps

In this document, we describe the steps required to perform the System RAM analysis. You can find a detailed description of how to perform each step in Chapter 3, "Using IMPRINT," of the IMPRINT User's Guide. Additionally, please be aware that the sequence of steps provided in this document are often just one method of performing the analysis. As with most Windows products, the same operations can often be performed just as effectively in a different order.

1. Begin a new analysis - Open IMPRINT. From the **File** menu, choose **New**. You will see a dialog box in which you must enter an Analysis Name and Version. Once entered, choose **OK**.

2. Define Soldiers - Begin by entering the MOS's for the soldiers that will be assigned to your new system. From the **Define** menu, choose **Soldiers**. Use the **Add** button to enter a list of MOS's that will maintain your system. Click on the **OK** button when you are finished.

3. Define Mission - From the **Define** menu, choose **Equipment**. You will see a dialog box that contains your Analysis Name, Version and Description. Click on the **Evaluate Design** button. You will see a dialog that contains a list of the subsystems within your system.

4. Add a new subsystem - Use the **Add** button. Enter a subsystem name. Use the combo box in the second column to indicate whether this subsystem is an Armaments, Mobility, or Other type. This indication determines how usage will be accrued to the components in the subsystem. Armaments subsystems accrue usage (and, therefore, fail) based on the number of rounds fired. Mobility subsystems accrue usage based on the distance traveled. Other subsystems accrue usage based on operating time. To begin entering components for your subsystem, select the subsystem and Click on the **Open** button.

5. Add the components to your new subsystem - Use the **Add** button. Enter a component name. To begin adding repair tasks for your component, select the component, and click on the **List Repair Tasks** button.

6. Enter repair task data - The component you selected will be listed at the top of the dialog box. Use the **Add** button to begin entering the repair tasks that will need to be performed on this component. You can choose from a set of task names. As you enter repair tasks, each repair task will be added to the spreadsheet. You can then move across the columns of the spreadsheet and set the maintenance parameters. The first and second column will be filled in for you based on the repair task that you chose. The third column is the **organizational level** at which the task will be performed. The next six columns are used to enter the **MOS**, **skill level**, and the **crew size** needed to perform the task. Notice that you enter two different MOS's (or the same MOS with two different skill levels). IMPRINT will make both these specialties busy for the entire length of the repair task. So if you have a repair task that doesn't require the attention of both MOS' for the entire length, you should break it into two tasks. The next column is the Mean Operational Unit Between Failure (**MOUBF**). This is the number that IMPRINT uses to predict when the repair task will be needed. The MOUBF is more typically called a MTBF in maintenance modeling literature, and is the inverse of the failure rate. The next three columns compose the specification of how long it will take to perform the maintenance task. The first of these columns is the Mean Time to Repair (**MTTR**). This value is in hours. This is a value representing the average time it takes to perform this maintenance action. This value and the standard deviation for the repair time (**SD MTTR**) are used to generate a simulated time for this maintenance action from the statistical **distribution** you choose in the next column. The final two columns include the probability that the need for this repair task will cause an ongoing mission to abort (**Abort %**) and an indication of whether this task could be performed by a **contact team**. Enter the repair data for each task in for your component. You can use

the **Next** and **Previous** buttons to move through all the components in your subsystem. Click on the **OK** button when you have finished.

7. Enter the remainder of your equipment data - Repeat steps 3-5 until you have entered a full description of your equipment. Once you have completed these steps, most of your work is done. You can exercise this equipment description against a wide variety of different scenarios with very little effort.

8. Save your results - Use either the **Save** tool on the IMPRINT tool bar or the **Save** command under the **File** menu to save your results. We recommend that you save often throughout your IMPRINT session.

9. Enter a scenario - Return to the Evaluate Design dialog, and click on the **Scenarios** button. This will open a list of existing scenarios. Use the **Add** button to add a new scenario.

10. Enter scenario data - Highlight a scenario name and click on the **Open** button. From this new dialog, you can decompose your scenario into segments, as well as enter Maintenance Crew Manning data, Travel Time Data, and Spare Data.

11. Decompose the scenario into segments - Click on the **Segments** button. This will open a dialog with a list of the mission segments. Use the **Add** button to add segments.

12. Enter the mission segment data - Highlight a segment and click on the **Operational Profile** button. This will open a dialog that contains all of the data items associated with a mission segment. Starting at the top of the dialog, enter the segment start time and day. If you want the mission segment to be scheduled for departure at 0800 on the first day of the scenario, then these values would be 08:00:00 and 1. Next, enter the Cancellation time. If the segment has not departed within this amount of time from the Departure Time, then the segment will be canceled. The next data item is the segment duration. The data item following that is the segment priority. This is used if two segments are competing for a limited number of available systems. The highest priority segment will be filled first. The next two data items are the minimum and maximum number of systems needed for this segment. The segment will not be canceled if the minimum number of systems are available prior to the departure time plus the cancellation time. If there are enough systems available, the segment will be filled with the maximum number of systems. The next two elements are the number per departure group and the time between departures. These two data items enable you to stagger the departures of your systems. You will also notice that you can set this mission segment to repeat periodically throughout the scenario.

13. Enter Combat Damage parameters - Click on the **Combat** button to enter the likelihood of your system sustaining combat damage during this segment, and if so, whether the system will be destroyed. If desired, you can enter the amount of time it

will take to repair combat damage, or if the system is destroyed, the amount of time it will take before the system can be replaced in the Unit's inventory. If the system undergoes repair due to combat damage, that repair time is NOT attributed to a specific subsystem or MOS. Rather, it is reported separately in the Combat Damage Report. It will, however, affect system availability. Click on the **OK** button to return to the segment dialog.

14. Enter Consumable data - Click on the **Consumables** button to enter the amount of rounds your system will fire and the distance it will travel during this mission segment. Also, you can enter the time needed to prepare the system for the segment. This is called the Load Time. This time will only delay the beginning of the segment. It will not affect failure rates. Click on the **OK** button to return to the segment dialog.

15. When you have finished entering these data, you can use the **Next** and **Previous** buttons to move through the rest of your segments. Use the **OK** button to exit back to the Scenarios dialog.

16. Enter Maintenance Crew data - Click on the **Maintenance Crew** button on the Scenarios dialog. In this dialog, you can enter the shifting information and the maintenance crew manning information, if you want to run your maintenance model with a limited maintenance crew. We recommend that the first time you run your maintenance model, you run it in an unconstrained mode. This will result in a maintenance analysis where system availability is maximized (because there will always be an unlimited number of soldiers available to maintain the system). Then, after you are satisfied that these results are reasonable, you should return to this screen and enter constrained maintenance crews in order to more realistically predict maintenance. Click on the **OK** button to return to the Scenarios dialog.

17. Save your results - Use either the **Save** tool on the IMPRINT tool bar or the **Save** command under the **File** menu to save your results. As mentioned above, we recommend that you save often throughout your IMPRINT session.

18. Execute the maintenance model - Access the **Execute** menu, and select the **Maintenance Model** option. Notice that you can vary the length of the run and the random number seed. Also, you must enter the number of systems that you want to include in your maintenance model. Remember to include enough systems so that you can meet the minimums on your segments. Finally, notice that there is a check box on this screen to indicate whether you want to turn the Crew Limits on. If you have entered maintenance crew sizes, yet you want to run the maintenance model in an unconstrained mode, just make sure that you "uncheck" this box. Press the **Run Model** button. When the model is finished, you will be reminded that you can access the results using the **Reports** menu.

19. View Reports - Access the **Reports** menu in IMPRINT and select the **Maintenance Model** menu item. You should review the Maintenance Summary, Daily

Maintenance, Reliability and Availability, Maintenance Hit Matrix, Daily Reliability and the Maintainability Report. You can select one or more reports by clicking on and highlighting the appropriate report title. The maintenance summary report contains four data items that summarize the maintenance requirements that were generated during the simulation. This report includes the average corrective and preventive maintenance man-hours that were simulated for each system. These are calculated by taking the total amount of man-hours in each category, and dividing by the total number of systems in the scenario. The average maintenance man-hours simulated per operational hour is also included. This is calculated by dividing the sum of the preventive and corrective maintenance manhours by the total operating hours. The Daily Maintenance Report contains the amount of maintenance manhours that were simulated at all organizational level types (e.g., ORG, DS, GS) for both maintenance types (e.g., preventive, corrective). The values in this report are totals across all systems. The Reliability and Availability Report has two parts. The first part is the Reliability Summary. It includes the number of segments requested and accomplished during the simulation. The report also includes measures for the number of times systems were requested, and the number of times that those system requests were accomplished. If you had one segment and a maximum of two systems assigned to that segment, then that will be reported as "Number of Times Systems Requested" = 2. If only one of the systems actually performed the segment, because the other system was either busy or in maintenance, then that will be reported as "Number of Times System Requests Accomplished" = 1. The second part of the screen includes an Availability Summary. The values are calculated as follows:

- Average inherent availability = ((scenario length in hours x # of systems) minus (total clock hours on corrective maintenance)) divided by (scenario length in hours x # of systems)
- Average achieved availability = ((scenario length in hours x # of systems) minus (total clock hours on corrective + preventive maintenance)) divided by (scenario length in hours x # of systems)
- Readiness = segments accomplished divided by segments requested

(Note that inherent and achieved availability consider the total number of days simulated in hours (e.g., 365 * 24), minus the number of clock hours spent in maintenance. Therefore, if 2 or more soldiers are working at the same time on the same system, it is counted just once. Similarly, if two maintenance tasks are being worked at the same time, it is only counted once). The Daily Reliability Report provides a summary of the number of segments and segment requests generated by the simulation for each day of the scenario. The Maintainability Report contains the simulated maintenance manhours per operational hour are included in this report. This is calculated by dividing the total manhours of maintenance performed on each subsystem by the total number of operational hours of the scenario. This report will provide a measure of your high driver subsystems.

20. If your system did not meet its RAM requirement, then there are a number of maintenance parameters you can adjust. First, you should adjust the intensity of your scenario to determine whether this variable is driving the RAM. You can decrease

segment duration and the number of segments per scenario to decrease the intensity. As an alternative, you can increase the number of maintainers in your crew so that the system can be maintained more quickly.

21. Rerun the analysis - In order to evaluate the impact of the modified scenario, you must rerun the analysis and review the reports in order to ensure that your system RAM is now acceptable.

Chapter 6 - Soldier Characteristics

Goals and Results

If you are interested in determining what types of soldiers (in terms of personnel characteristics such as mental aptitude, reading grade level, etc.) may be available to operate, maintain, and support a system, you will want to conduct a “Define Soldier” analysis. By the same token, if you want to determine what types of people are currently in an MOS or are projected to be in an MOS, you should also use this type of analysis. The “Define Soldier” module lets you select MOSs that are likely to be available (probably from a predecessor system) to operate and maintain the new system. It then permits you to “project” the MOSs into the future, when the new system will be fielded, to obtain estimates on their personnel characteristics. Since, quite often, the system being supported by this analysis will not be fielded until sometime in the future, it is important that the personnel characteristics, and thus the performance of the operators and maintainers, be related to that time frame rather than now.

The results from the Define Soldier analysis are accessed through the **Reports** menu in IMPRINT. The reports address the following personnel characteristics by MOS and year:

- **Gender (male & female)** - Gender is tied very closely to the physical differences that may impact performance on selected tasks that a specific specialty (or MOS) will require.
- **Education (high school graduate & non high school graduate)** - Whether an individual is a high school graduate is a good indicator of the individual’s trainability and amenability to the discipline required to make it through basic training.
- **Test Score Category (I, II, IIIA, IIIB, & IV)** - One of the personnel characteristics of most interest is Test Score Category. This is because it is not only a good indicator of an individual’s trainability but also a good predictor of performance.
- **Armed Services Vocational Aptitude Battery (ASVAB) Score Distribution (0 - 135)** - ASVAB Score is tied very closely to the aptitude and knowledge required to perform tasks that a particular specialty (or MOS) will require.
- **Reading Grade Level (<7 - >12)** - Reading Grade Level is obviously related to training materials, job aids, and instructional manuals from which soldiers must be able to comprehend the information being presented.
- **Weight Lift** - Weight Lift is tied very closely to the physical requirements to perform tasks that a particular specialty (or MOS) will require.
- **Psychological, Upper Extremities, Hearing, Lower Extremities, Eyes, Stamina (PUHLES) Eyes (1, 2, & >2)** - The eyes rating from the PUHLES score is tied very closely to the visual requirements of the tasks that a particular specialty (or MOS) will perform.

Mental Model

Personnel characteristics are important because they can be good predictors of how well soldiers will be able to perform mission critical tasks. It is well known that soldiers with higher mental aptitude scores perform most tasks, especially cognitive type tasks, more accurately and in less time than soldiers with lower mental aptitude scores. As the Army acquires more technologically sophisticated systems that require cognitive skills, rather than physical skills, it is important to determine if current MOSs will have the types of people needed to support those systems.

It is not only a good idea to see what types of people are in an MOS today, but also to see who is likely to be in that MOS when a new system is scheduled to be fielded. The personnel projection model in IMPRINT uses historical trend data to estimate the types of people likely to be in that MOS in future years. Obviously, the further into the future the projection, the less likely the estimate will be correct.

This analysis can answer the following types of questions:

- What percentage of the soldiers in this MOS are Test Score Category IV?
- What is the expected reading grade level of the crew?
- Will this MOS likely have more females in it eight years from now?
- Are there major differences in the types of people in these MOSs?
- What percentage of this MOS are high school graduates?

Special Guidance

A personnel flow model is used to make projections of what the selected Military Occupational Specialties (MOSs) are likely to look like in the future. The projections are based on historical trend data contained in the IMPRINT library. There is also an option within this module that allows you to change the historical trend data to reflect more recent personnel policies. You should be very careful when changing historical trend data (i.e., separation rates, promotion rates, etc.) since there are many interdependencies within the flow model that could produce unrealistic results if the changes made are not logical. The personnel flow model employs a modified Markov Chain algorithm to apply accession, continuation, promotion, and migration probabilities to determine projected inventories.

Please note that the personnel data in IMPRINT are indicated by a certain date (e.g., the end of FY97 or 31 September 1997). IMPRINT is updated periodically with personnel data from PERSCOM databases. The personnel transition rate data for IMPRINT Version 4.0 are from FY97 records. The personnel inventory data are as of 31 September 1997. The accuracy with which IMPRINT will describe MOSs is obviously dependent on when the data were last updated. Also, there are constant changes in the Enlisted Personnel Classification System whereby MOSs are deleted, created, and consolidated. IMPRINT personnel data may or may not reflect these changes, depending on when the data where last updated. The personnel projection model will only plan 20 years into the future.

The MOSs you select in this option will be available to the rest of the analysis under Define Mission, Define Equipment, and Define Force Structure menu options.

Data Requirements

All the data needed in this option are contained in IMPRINT libraries and provided automatically to users. The model operates at the MOS, grade, year of service, and quality/demographic level of detail. It begins with the current inventory from the Army's Enlisted Master File (EMF). It also uses the EMF to calculate historical transition rates (e.g., separations, promotions, migrations, etc.) for each subpopulation in an MOS. Subpopulations are defined by gender, high school graduate status, and test score category. The model also uses historical accession data from the EMF, Army end strength projections from the Army Program Objective Memorandum (POM), and estimated available accessions from an Army Research Institute (ARI) propensity to enlist study.

The only required user data are the MOSs to be projected and the ending year of the projection. You can select both of these from lists. You have the option of adding or deleting MOSs from the MOS list. Also, as mentioned before, you can edit the flow model parameters (i.e., transition rates, available accessions, etc.).

Analysis Steps

1. To begin developing estimates of future personnel characteristics, choose the **Soldiers** option from the **Define** menu.

2. Then, from the Define Soldiers dialog, adjust (by adding or deleting) the MOS list to include all MOSs for the analysis. After that click on the **Projection** button.

3. From the Projection dialog, select the MOSs to be projected and the ending year of the projection. As an option, edit model parameters by selecting the appropriate parameter button.

4. Click on the **Run Model** button to run the flow model.

5. After the flow model runs, go to **Reports** on the main menu to see the results. The reports interface allows you to tailor the reports to selected subpopulations within the MOSs.

Chapter 7 - Army Wide Manpower Requirements

Goals and Results

You can use the Define Force Structure capability in IMPRINT to develop Army-wide estimates for manpower required to operate, maintain, and support a weapon system. The objective of the force analysis is to project Army-wide manpower and personnel requirements for a new weapon system. This is accomplished by estimating manpower and personnel requirements for a "pacing unit" and then extrapolating those results to estimate requirements for other units in the Army. The major output of the force analysis are data that can be used to construct a Manpower Estimate (ME) report. The ME report is a Congressionally mandated report that is due at Milestone II in the acquisition cycle.

Although Define Force Structure can be used in a "stand alone" mode (i.e., without running through Define Mission, Define Equipment, or Define Soldiers first), the most common case will be to use it last after conducting the other analyses.

Mental Model

The Army is generally constrained by Congress to a fixed endstrength. If a new system being introduced into the Army will require more manpower than its predecessor system, then the Army will be required to remove manpower from another system or function to support the new system. If, on the other hand, a new system being introduced into the Army will require less manpower than its predecessor system, then the Army can allocate the additional manpower to other systems or functions.

Because of this, there is a keen interest in the overall manpower impact of a new system. The overall manpower includes operators, maintainers, trainers, and all other support people required by the new system. IMPRINT is able to help determine the overall manpower requirements by estimating the total number of operators and maintainers required for a new system during its fielding and steady state. Not only may the number of people required for a new system be different than its predecessor, but the types of people needed may be different as well. For example, the predecessor system may have had an extensive hydraulic system requiring maintainers with hydraulic repair skills. The new system, on the other hand, may have no hydraulics and instead have a "drive by wire" system that requires electrical and computer repairmen.

The Define Force Structure analysis can answer the following types of questions:

- What units will have predecessor systems replaced by new systems?
- How many new systems will be fielded?
- How many people in this maintenance MOS will be required in 2006?
- What are the total operator and maintainer manpower requirements when the system is fully fielded?

Special Guidance

Prior to performing this type of analysis, you should go to the Define Soldiers capability and add MOS's to your analysis. This process is described in Chapter 6, "Soldier Characteristics" of this Analysis Guide.

Normally, you will have run a maintenance simulation in Define Equipment using a representative unit (or "pacing" unit) in which the new system will be fielded. Pacing units can be thought of as major building blocks within Divisions and Corps. In many cases pacing units will be battalions. For example, when modeling weapon systems in Infantry and Armor units, it is recommended that a battalion be modeled. In another case, if modeling a new system for a chemical unit, it is recommended that a company be modeled. The idea is to determine manpower requirements for the pacing unit, via modeling, and then multiply those manpower requirements by the number of those units in the Army, to get Army-wide manpower requirements.

Data Requirements

In Define Mission, you specify the crew members (and therefore crew size) for each weapon system. Define Force uses the specified crew size as a basis for estimating Army-wide requirement for operators of the new system. The number of required operators is a function of the types and numbers of units receiving the new system, the number of new systems being fielded, and the crew ratio. Default values are provided for the crew when Define Mission was not exercised.

The maintenance manpower requirements in Define Equipment for the simulated unit (i.e., pacing unit) will be used in Define Force Structure to compute manpower requirements for units in which the new system will be fielded. The data from Define Equipment will provide the basis for estimating Army-wide manpower requirements for all other types and sizes of units. Default values are provided for those units not modeled in Define Equipment.

This does not mean that you cannot change the Define Equipment numbers once they are brought into Define Force. You will have the option to edit them in Define Force. You can change the Define Equipment data by choosing to edit MMHs. The number of required maintainers is a function of the number and type of units, number of systems to be fielded, system reliability, maintenance ratio, operating tempo, and battle damage.

Analysis Steps

1. Select **Force Structure** from the **Define** option on the IMPRINT main menu.

2. Initially, you identify the types and quantities of units in the Army Force Structure for which manpower requirements will be computed. These will be the units in which the new system is scheduled to be fielded. The Define Force Structure dialog is used to develop the list of all units that will be getting the new weapon system. Use the **Add** button to add one or more parent units to the list. After clicking on this button, you can select from a list of parent units or type in a parent unit. Use the **Delete** button to remove highlighted parent units from the dialog list.

3. If you do not know what units to include in the Force Structure, you have the option of including all units. Define Force will automatically provide a list of all units that have the type of weapon system for which the analysis is being conducted. You can then edit this list. The result is a list of active Army TOE units, by type and number, with the number of systems to be fielded, by year, for each type of unit.

4. You can use the Unit Parameters dialog to specify the several data elements for each unit. First, **Annual Op Tempo** is the number of hours per day that the new system is expected to operate in the type and size unit listed. **Measure** is the unit used to measure op tempo (e.g., flight hours, miles driven, etc.). **Annual MMHs/system** are the total number of annual maintenance man-hours (by maintenance level) required to maintain one new system in that unit. Finally, **Crew Ratio** is the average number of crews available for each new system in the unit. In some cases where systems are required to operate continuously there may be multiple crews for each system.

5. To review Army-wide manpower requirements go to **Reports** on the IMPRINT main menu and then select **Force Structure**.

Chapter 8 - Changing Personnel Characteristics

Goals and Results

Under the Options menu in IMPRINT, there is a menu item for PTS. This lets you access the Personnel Characteristics, Training Frequency and Stressor data for your analysis. We recommend that you make adjustments in these areas in the same order of the tabs (i.e., P, then T, then S). This is because the Personnel Characteristics describe the attributes that will arrive with the soldiers manning your system. Then, you can train those soldiers to perform the tasks. Finally, when the soldiers perform the tasks, they will be subjected to environmental stressors.

The Personnel Characteristics option allows you to change the Armed Services Vocational Aptitude Battery (ASVAB) composite and cutoff score for the Military Occupational Specialty (MOS) performing the tasks. The current ASVAB composite and cutoff score (used to select people for the MOS) are defaults. You can change these values to investigate changes in performance. Higher cutoff scores will normally result in better performance (i.e., more accurate and less time) but will cause less people to be available for the MOS.

Mental Model

Personnel characteristics are important because they can be good predictors of how well soldiers will be able to perform mission critical tasks. It is well known that soldiers with higher mental aptitude scores perform most tasks, especially cognitive type tasks, more accurately and in less time than soldiers with lower mental aptitude scores. As such, one option in obtaining better system performance is to assign a crew with higher mental aptitude scores to the system. This equates to raising the ASVAB cutoff score. The cost of doing this reduces the number of people that will be available to serve as a crew member.

If a new system will require the operators to perform tasks that weren't required in the predecessor system, the possibility of creating a new MOS to operate the system could be an alternative that should be investigated.

You can use the Personnel Characteristics option to answer the following types of questions:

- If I raise the operator MOS cutoff score to 105, will I achieve my mission performance standard?
- How many in the current MOS will be available if the cutoff score is raised to 105?
- How much better do Test Score Category I soldiers perform these tasks than do Test Score Category IV soldiers?
- What is the trade-off between increased performance and personnel availability?

- What is the difference between current cutoff scores for these two MOSs?

Special Guidance

Prior to performing this type of analysis, you should go to the Define Soldiers capability and add MOS's to your analysis. This process is described in Chapter 6 of this Analysis Guide. If you have not selected MOS's or if you have only officers, or if you have not entered Taxons on the Task Information dialog, then you will not be able to use this option.

Changing personnel characteristics is one of three options (the other two are changing sustainment training frequency and applying stressors) that you can select to influence task and therefore mission performance. Because of the way in which these options are calculated, they should be exercised in a particular order. Changing personnel characteristics should be done first, then changing sustainment training frequency, and applying stressors last.

The reason for this is avoid the potential for getting negative numbers for performance accuracy. Since stressors have greater impacts on performance than do the other two options, it is quite likely that applying a severe stressor (e.g., 76 hours without sleep) will cause task accuracy to be near zero. If this severe stressor were applied first, rather than last, it is possible that the other optional adjustments will get a negative accuracy value. Once again, this is because of the way the adjustments are calculated. For example, the stressor adjustment is made by multiplying the mean accuracy by a computer degradation factor. The sustainment training adjustment, on the other hand, is made by subtracting a computer value from the mean accuracy.

The prediction equations for changes in performance based on changes in personnel characteristics are based on data from Project A. Project A is an Army Research Institute effort that involves measuring soldiers' performance on many different types of tasks. The original prediction equations were based on Project A data from the mid-1980's. The prediction equations have since been updated based more resent (mid-1990's) Project A data.

When choosing an ASVAB composite cutoff score, you should realize that a higher cutoff score will generally result in better performance within the MOS; however, there will be fewer people available that can attain the higher cutoff score. The number of people available in an MOS at each cutoff score can be seen in the "Availability vs ASVAB Cutoff" report in the personnel characteristics report section.

There are two options for setting minimum (i.e., cutoff) scores for personnel characteristics. Both options involve measures obtained from the Armed Services Vocational Aptitude Battery (ASVAB). The ASVAB is a battery of tests administered to enlistees prior to entering the military services. It is important to note that changes in the Test Score Category Cutoff will cause IMPRINT to automatically update the ASVAB Composite Cutoff to reflect the new Test Score Category that you have selected.

IMPRINT will also automatically update the Test Score Category Cutoff to reflect changes you make to the ASVAB Composite Cutoff. The two options are as follows:

1. Change Test Score Category Cutoff - This option allows you to set a minimum "mental category" for a Military Occupational Specialty (MOS) and then see how performance would be affected. Mental category (now called "Test Score Category") refers to the score obtained on the Armed Forces Qualification Test (AFQT), which is derived from the ASVAB. The different Test Score Categories are:

Test Score Category	**AFQT Score**
I	93-99
II	65-92
IIIA	50-64
IIIB	31-49
IV	10-30

   When you pick a Test Score Category cutoff, the MOS will include the chosen Test Score Category and all others above it (e.g., Choosing "IIIA" will result in the MOS having mental categories I, II, and IIIA). IMPRINT will automatically estimate the ASVAB cutoff that is associated with the Test Score Category cutoff you select.

2. Change ASVAB Composite Cutoff - This option allows you to set a minimum ASVAB Composite score for the MOS and then see how performance would be affected. The ASVAB itself consists of 10 sub-tests from which "composites" are constructed by combining two or more of the sub-tests. Each MOS uses one or two of the composites to control who can enter the MOS. Setting composite cutoff scores, which must be attained in order to enter the MOS, does this. Each MOS is assigned a composite that is best for measuring the skills and aptitudes required to perform jobs well in the MOS.

It is important to note that any personnel characteristic changes that you make may alter the stored accuracy, time, and/or probability values that IMPRINT has for that particular task or MOS, within your analysis. If you make personnel characteristic changes, IMPRINT will produce a "Delta" Report that will show you how task performance has been changed. When this "Delta" Report is produced, you should print this report (either to a file or to your printer) in order to maintain a record of your changes. This record is important because you can make further changes in other places in IMPRINT. As these changes add up, it can be difficult, if not impossible, to regain your initial values. You should print any subsequent "Delta" Reports as well.

If you have not selected any MOSs, or you have only officers, or you have not put assigned taxons to tasks, you will not be able to access or use this option.

Data Requirements

You select the ASVAB Composite and Cut-off Score or the Test Score Category to apply to selected tasks. You select these from drop down lists.

Analysis Steps

1. From the **Options** menu item, chose **PTS**. This will open a dialog that shows Personnel Characteristics, Training Frequencies, and Stressors on tabs at the bottom of the dialog. Select the **Personnel Characteristics** tab. This option allows you to change the Armed Services Vocational Aptitude Battery (ASVAB) composite and cutoff score for the Military Occupational Specialty (MOS) performing the tasks.

2. You can apply this change to selected tasks or to all tasks assigned to a particular crewmember or position.

3. The current ASVAB composite and cutoff score (used to select people for the MOS) are shown initially in the dialog box. You can edit these values. First you can select the ASVAB composite to be used from a drop down menu that will appear when you click on the drop down control. The same method is used to edit the field labeled "Cutoff."

4. Once you have selected a particular Test Score Category, you can see a report summarizing the impact that your choice has had on task Accuracy, Time, and the Probability of achieving the minimum acceptable accuracy by clicking on the **Review** button.

Chapter 9- Changing Sustainment Training Frequency

Goals and Results

Under the **Options** menu in IMPRINT, there is a menu item for PTS. This lets you access the Personnel Characteristics, Training Frequency and Stressor data for your analysis. The Training Frequency option allows you to review and edit training frequencies for each task. One of five training levels can be assigned to a task. You should choose the training level which best describes how often operators or maintainers perform the task. Performance of the task could be part of a training exercise or actual job performance. In general, the more frequently an individual practices or performs a task, the more accurately they will perform it. Also, an increase in training frequency will normally decrease the time required to perform the task.

Mental Model

One way to improve system performance is to train more frequently on critical tasks or missions that must be performed. The cost of doing this is obviously in terms of training resources (fuel, ammo, time, etc.) required. The type of training addressed here is sustainment training in operational units and not the type of training received in the schools or initial entry training.

This capability in IMPRINT can be used to answer the following types of questions:

- If I raise the training frequency to once a week will I achieve my mission performance standard?
- What is the trade-off between increased performance and increased training frequency?

Special Guidance

Prior to performing this type of analysis, you should go to the Define Soldiers capability and add MOS's to your analysis. This process is described in Chapter 6, "Soldier Characteristics" of this Analysis Guide.

If you are trying to improve task performance to meet accuracy or time standards, increasing training frequency is one possible alternative. An increase in training frequency, however, will often require additional resources (e.g., an increase in the frequency with which soldiers zero the sights of their weapons will require more ammunition). If you do not assign sustainment training frequencies to tasks, the average (i.e., once a month) will be assigned automatically.

You should choose the training level which best describes how often operators or maintainers will perform the task. Performance of the task could be part of a training exercise or actual job performance. In general, the more frequently an individual practices or performs a task, the more accurately they will perform it. Also, an increase in training frequency normally will decrease the time required to perform the task.

It is important to note that any training frequency changes that you make may alter the stored accuracy, time, and/or probability values that IMPRINT has for that particular task or MOS, within your analysis. If you make training frequency changes, IMPRINT will produce a “Delta” Report that will show you how task performance has been changed. When this “Delta” Report is produced, you should print this report (either to a file or to your printer) in order to maintain a record of your changes. This record is important because you can make further changes in other places in IMPRINT. As these changes add up, it can be difficult, if not impossible, to regain your initial values. You should print any subsequent “Delta” Reports as well.

Data Requirements

To perform this analysis you select from one of five training frequencies for selected tasks.

Analysis Steps

1. From the **Options** menu item, chose **PTS**. This will open a dialog that shows Personnel Characteristics, Training Frequencies, and Stressors on tabs at the bottom of the dialog. Select the **Training Frequency** tab. This option allows you review and edit training frequencies for each task. One of five training levels can be assigned to a task.
2. You can apply this change to selected tasks or to all tasks assigned to a particular crewmember or position.
3. Select the tasks to which you want to apply the training frequency adjustment.
4. Select from one of five training frequencies, from a drop down list, for selected tasks. Then click on the **Apply** button.
5. In order to see the effects of changing training frequencies you should click on the **Review** button. Once you have finished applying a training frequency, it is recorded for that particular Task or Military Occupational Specialty (MOS) and can be referred to or edited later.

Chapter 10 - Applying Stressors

Goals and Results

Under the **Options** menu in IMPRINT, there is a menu item for PTS. This lets you access the Personnel Characteristics, Training Frequency and Stressor data for your analysis. There are five different stressors that can be applied to tasks. They are: Mission Oriented Protective Posture (MOPP) gear for individual nuclear, biological, and chemical defense; heat; cold; noise; and sustained operations (i.e., lack of sleep). Stressors may be reviewed and changed for each individual task, one at a time, or, for an entire group of tasks, all at once. Depending upon the specifics of the task and MOS, adding stressors may decrease task accuracy and/or increase the time it takes to complete the task.

Mental Model

Performance on a task or mission under ideal conditions may differ drastically from performance on the same task or mission under stressful conditions. The environment in which military operations (tasks and missions) are conducted can be very stressful. IMPRINT provides performance prediction equations for 5 different environmental stressors (listed above) that can impact performance. This allows you to estimate mission performance under “worst case” conditions.

An analysis of this type will enable you to answer the following questions:

- Can the crew still emplace the Howitzer in 2 minutes or less when they are required to be in MOPP IV?
- Which will degrade performance on this task the most--extreme heat or extreme cold?
- What is the combined effect of lack of sleep and extreme heat on mission performance?
- Which stressor will degrade time and accuracy the most on these tasks?
- Which of these tasks will be degraded (in terms of performance) the most by this stressor?

Special Guidance

It is important to note that any stressors that you apply may alter the stored accuracy, time, and/or probability values that IMPRINT has for that particular task or MOS, within your analysis. If you apply stressors, IMPRINT will produce a "Delta" Report that will show you how task performance has been changed. When this "Delta" Report is produced, you should print this report (either to a file or to your printer) in order to maintain a record of your changes. This record is important because you can make further changes in other places in IMPRINT. As these changes add up, it can be difficult, if not impossible, to regain your initial values. You should print any subsequent "Delta" Reports as well.

In order to see the effects of stressors you should apply them one at a time (i.e., apply a stressor and run the model to see the impacts; then apply another stressor and rerun the model to see additional impacts). Although it is possible in IMPRINT to apply multiple stressors at the same time, the overall performance effects cannot be broken out and attributed to individual stressors.

In order for stressors to affect task performance, each task must be assigned to Taxons. The table below indicates the impact of stressors by taxon.

TAXON	MOPP	Heat	Cold	Noise	Sleepless Hours
Visual	T	A	T		
Numerical		A			TA
Cognitive		A			TA
Fine Motor Discrete	T	A	T		
Fine Motor Continuous					
Gross Motor Light	T		T		
Gross Motor Heavy					
Commo (Read & Write)		A			
Commo (Oral)	T	A		A	

T = Affects task time. A = Affects task accuracy TA = Affects both

For more detailed information on how the stressors are used to affect task time and accuracy, please refer to the Appendix in the IMPRINT User's Guide. It contains a technical paper, "Evaluation of Human Performance under Diverse Conditions via Modeling Technology" (Allender, Salvi, Promisel) that describes these relationships.

Data Requirements

You can select the stressor and the levels (e.g., for the heat stressor, the levels are temperature and relative humidity) to apply from drop down lists. Although it is possible in IMPRINT to apply multiple stressors at the same time, it is recommended that they be applied one at a time to see the effects of each. In order to apply stressors, you must have assigned Taxons to the tasks. You can do this by accessing the Task Information dialog (through the Define Mission option), and using the Taxons tab. For more information, see Chapter 3, "Using IMPRINT" in the IMPRINT User's Manual.

Analysis Steps

1. From the **Options** menu item, chose **PTS**. This will open a dialog that shows Personnel Characteristics, Training Frequencies, and Stressors on tabs at the bottom of the dialog. Select the **Stressors** tab. This option allows you review and edit stressors for each task.

2. You can apply this change to selected tasks or to all tasks assigned to a particular crewmember or position.

3. Select the tasks to which you want to apply the stressor adjustment.

4. Select a stressor and the stressor levels from drop down lists, for selected tasks. Then click on the **Apply** button.

5. In order to see the effects of applying stressors you should click on the **Review** button on the Apply Stressors dialog box. Once you have finished applying a stressor, it is recorded for that particular Task or Military Occupational Specialty (MOS).